A Prospective Observational Study To Develop A Paediatric Acute Care Score (PACS) For Early Prediction Of Clinical Deterioration Requiring Intensive Care In Children Presenting To Paediatric Emergency Services In A Tertiary Care Hospital.

A dissertation submitted in partial fulfilment of the rules and regulations for MD Paediatrics examination of the Tamil Nadu Dr.M.G.R Medical University, Chennai, to be held in April 2016

DECLARATION

This is to declare that this dissertation titled, **" A Prospective Observational Study To Develop A Paediatric Acute Care Score (PACS) For Early Prediction Of Clinical Deterioration Requiring Intensive Care In Children Presenting To Paediatric Emergency Services In A Tertiary Care Hospital."** is my original work done in the partial fulfilment of the rules and regulations for MD Paediatrics examination of the Tamil Nadu Dr.M.G.R Medical University, Chennai to be held in April 2016

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CERTIFICATE

This is to declare that this dissertation titled, **" A Prospective Observational Study To Develop A Paediatric Acute Care Score (PACS) For Early Prediction Of Clinical Deterioration Requiring Intensive Care In Children Presenting To Paediatric Emergency Services In A Tertiary Care Hospital."** is a bonafide work done by Dr.Vandana Pande in the partial fulfilment of the rules and regulations for MD Paediatrics examination of the Tamil Nadu Dr.M.G.R Medical University, Chennai to be held in April 2016.

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Title: **A Prospective Observational Study To Develop A Paediatric Acute Care Score (PACS) For Early Prediction Of Clinical Deterioration Requiring Intensive Care In Children Presenting To Paediatric Emergency Services In A Tertiary Care Hospital**

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Aims & Objective-

To develop and validate a simple scoring system- PACS (Paediatric Acute Care Score) using the clinical vital variables and co morbidities, for sick children admitted to paediatric wards through emergency department ;To determine early prediction of clinical deterioration requiring intensive care or high dependency.

Methodology- This was a prospective observational study to analyze the hypothesis that the clinical assessment using the simple scoring system- PACS at the time of presentation to emergency room (T0) and at the time when admission was decided (T1) can predict the clinical deterioration early. The study was conducted in the Paediatric Emergency Department and the paediatric wards of CMC, Vellore. All children (aged between 28 days of life to completed 17 years), who require admission to the paediatric ward are enrolled into the study after obtaining the written informed consent from the parents and their demographic details, primary diagnosis, co-morbid factors and PACS are documented in a standardized proforma. The children who need ICU Care as per the Physician's opinion at admission itself and neonates were excluded from the study The primary outcome of "Clinical Deterioration" was defined as 1. Cardio-pulmonary arrest ,2. Respiratory failure requiring intubation,3. Worsening respiratory distress leading to respiratory support in the form of Non-invasive ventilation or high flow oxygen therapy ,4. Worsening of shock requiring > 10 mcgm/kg/min Dopamine and or addition of a catecholamine / vasopressin and or increasing lactate level of more than 2 from the baseline/metabolic acidosis,5. Deterioration of sensorium –i.e. drop in Glasgow Coma Scale (GCS) >/= 2 since admission to the ward and 6. Persistent, uncontrolled seizures after two long active anticonvulsants, requiring continuous anticonvulsant infusion.. The admitted children were followed up for 48hours to look for any clinical deterioration.

Results- Among the 560 patients who are admitted, 443 (80%) were discharged after complete recovery. The remaining 117(20%) children deteriorated during the course of hospital stay. Among which 101(87%) children deteriorated within 48 hours of admission and 16(13%)children deteriorated after 48 hours of admission. The most common type of clinical deterioration within 48 hours of admission(n=101), was respiratory failure requiring intubation, n=48(48%) followed by worsening of respiratory distress requiring Non-invasive ventilation or high flow oxygen therapy, n=23(23%). The other forms of clinical deterioration are worsening of shock requiring hiking of inotropes (n=17,17%), cardiopulmonary arrest (n=11, 11%), worsening of sensorium (n=1,1%) and Persistent, uncontrolled seizures (n=1, 1%).At a score of $\geq$ 4 The score has sensitivity of 87% with specificity of 99% and AUC of 0.95.Hence children with PAC score of $\geq$ 4 at the time of admission have more risk of deterioration within 48 hours of admission

Conclusion-1.The PAC score is a fairly accurate scoring system (AUC-0.95) in identifying the risk of 'clinical deterioration' of sick children within 48hours of admission.2. The children with PAC score of $\geq$ 4 have more chance of clinical deterioration within 48 hours of admission compared to those with PAC score of <4.(Sensitivity-87% and Specificity-99%).

INTRODUCTION

The identification of a sick child or a deteriorating child is very imminent for the immediate treatment .The immediate attention to the sick child will either pave a way for the reversal of the impending danger or delay the emergent crashing so that the medications can work upon and give time for the body to cope up with the illness.

The deterioration of children is very difficult to recognise and predict because of the varied presentations of illness which are very unique to children and are age dependant. Children also cannot articulate the various reasons for the sickness and have very meagre compensatory mechanisms. With the advancing technology in the recent years being available, the inpatient deterioration and cardiac arrests of the children in the wards of the hospital are avoidable or can be avoided completely. With careful and early detection of deterioration with the use of early warning scores and appropriate timely intervention given, these deteriorations can be reduced.

The purpose of this prospective observational study was to assess the use and validation of the Pediatric Early Warning Scores (PEWS) for the prediction so that children who can clinically deteriorate in the course of their stay in the pediatric wards can be monitored more frequently than already done. The co-morbidities of the children who present to a referral centre like Christian Medical College has to be taken into consideration, to be able to derive a de novo score for the day to day use and clinical follow up.

AIMS

&

OBJECTIVES

AIM

To develop a simple scoring system using the clinical vital variables and co morbidities for sick children who are admitted to pediatric wards through Pediatric Emergency Service and to determine the early prediction of clinical deterioration requiring intensive care.

OBJECTIVE

To validate a simple scoring system - PACS (Paediatric Acute Care Score) for the early prediction of clinical deterioration requiring intensive or high dependency care in children admitted to the Pediatric wards through PES.

LITREATURE REVIEW

LITREATURE REVIEW

The potential and ability of sick children to withhold the stress during the time of illness is very low and they can deteriorate very rapidly as compared to adults, if the intervention is not done at appropriate time. The sick children presenting to Emergency Services with obvious compromise of the airway, breathing and circulation are transferred to the Intensive Care Unit for further management. Clinical deterioration of children who are not very sick and are subsequently admitted to the wards might have unexpected death or unplanned admission to the intensive care unit. The challenge to prevent unexpected clinical deterioration in the hospital lies in the ability of the health care provider to identify the early warning signs of deterioration and to intervene at the appropriate time. The number of lives thus saved can be extrapolated to the national mortality and morbidity burden contributed by illness and ICU care. Hence any effort should be analysed and the results can be implemented in a resource limited country like India.

The inpatient hospital cardiac arrests lack the data collection and analysis. Arrest in Pediatrics can be due to three complications through the inpatient care- respiratory arrest, severe bradycardia, and pulseless cardiac arrest(1).These conditions are recorded with varied interchangability. In the early 1990s, international experts developed the Utstein style for data reporting of cardiac arrests and resuscitation (2). The American Heart Association started a National Registry of Cardiopulmonary Resuscitation (NRCPR) to collect a large database of hospital cardiac arrests and

resuscitation with Utstein style definitions. The outcome measures are all recorded to determine any intervention that could have been done for averting a death.

Advances in resuscitation care-like BLS courses in the decade have resulted in increasing rates of survival for patients with out-of-hospital cardiac arrest(3). In the in-hospital setting, efforts to improve quality include the use of routine mock codes, post-resuscitation debriefing, and defibrillation machine brought by the specialised code personnel. Code teams respond to sudden arrests that occur in the hospital and resuscitate within the window period of 3-5 min for return of spontaneous circulation. In the hospitalized children, 0.7% to 3.5% of them have cardiopulmonary arrest during the course of stay, with only 15-36% of children surviving the arrest (1). Despite technological and pharmaceutical advances, the survival rate of the children who have unexpected deterioration after admission has not improved. This unexpected clinical deterioration can be prevented by the following interventions:

1. The implementation of CART (Cardiac Arrest Resuscitative Team) /an outreach of the ICU team to resuscitate children with cardiopulmonary arrest and
2. The use of early warning scores. - developed depending on the relevant predictors of clinical deterioration.

Intervention before the cardiopulmonary arrest

1. Monitoring Vital Signs

Many studies have shown changing trends in the vital signs before cardiac arrest and sudden ICU transfer. In one large study done by Matthew et al, (4) patients hospitalized to the wards at an academic hospital were included in the study. The vital

signs noted in the wards were compared across outcomes. Using the area under the receiver operating characteristic curve (AUC) it was found that the patients transferred to the ICU had a lower oxygen saturation and higher mean heart rate than the patients who remained in the wards. Fever, hypoxia, tachycardia, mental deterioration and hypotension were significantly present before the cardiac arrests in the ward.

In another adult study done by Hodgetts et al (5), 118 cardiac arrests in adult patients in the hospital were randomised and compared with 132 non-arrest patients. The most common factors before the cardiac arrest were abnormal values of respiratory rate ($P = 0.013$), heart rate ($P < 0.001$), pulse ($P < 0.001$), systolic blood pressure ($P < 0.001$), temperature ($P < 0.001$), pulse oximetry ($P < 0.001$), chest pain ($P < 0.001$) and doctor or nurse concern ($P < 0.001$).

Several studies indicate that warning signs precede almost all critical inpatient events by an average of 6-8 hours (6, 7). Such warning signs include: change in vital signs such as tachycardia, hypotension, acute dyspnoea, and dip in level of consciousness. There is a paucity of definite derivations in children due to the wide range of the normal vital parameters which vary with age and sex of the child. There are many studies looking into the vital signs which have been included into the calling criteria for the MET/RRT teams responsible for reducing the clinical deterioration.

Recently, eleven studies were included into a systematic review by Chapman et al (8) to identify the number and nature of published alert criteria and to evaluate their

validity, reliability and clinical effectiveness. Evidence regarding the validity, reliability and utility of pediatric alert criteria in well-conducted studies are very useful for the detection of the sick child and these ranges helps in the identifying the children in a big way much before the deterioration with appropriate use of the monitors and resources thus avoiding unnecessary cost and trauma to the patient.

Table 1. The cut off points used in the children in various studies

Author	Age range	HR	RR	Blood pressure(Sys)	Spo2	Comments
Brilli	All				<90%	Agitation or decreased level of consciousness
Duncan	<3m 3-12m 1-4y 4-12y >12y	110-150 100-150 90-120 70-110 60-100	30-60 25-50 20-40 20-30 12-16	60-80 80-100 90-110 90-120 100-130	<95%	
Edwards	<1y 1-2y 2-5y 5-12y >12y	90-160 80-150 75-140 60-120 55-100	20-50 15-45 15-40 10-35 10-30	70-90 80-95 80-100 90-110 100-120	<92%	
Haines	0-6m 6-12m 1-5y 5-12y >12y	>150 >150 >120 >100	>70 >60 >40 >25 >25	Signs of shock	Decrease in Sat	
Manoghan	All	>20	>10			Sleeping/Lethargic/confused/reduced pain response
Sharek	All	Acute change	Acute change	Acute change	Acute change	Acute change
Tibballs	<3 m 4-2m 1-4y 5-12y >12y	100-180 100-180 90-160 80-140 60-130	60-50 50-60 40-70 30-80 30-90		<90%	Acute change
Tucker	All	Tachycardia of 20	>10		<90%	Sleeping/Lethargic/confused/reduced pain response

More studies are needed for the determination of sensitivity, specificity and age related thresh holds of each vital sign parameter in Indian Population. There are no studies with normal values for age, sex and variations in Indian population. Continued monitoring and wireless technology studies have to be undertaken.

2. Medical Emergency Resuscitation Teams

Medical emergency teams (METs) or Resuscitation response Teams (RRT) are healthcare professionals that get assembled in response to life threatening events or clinical deterioration and enable hospitals to respond more effectively to inpatient deterioration before a cardiopulmonary arrest occurs with the intention of preventing the arrest from occurring. The RRT is based on the notion of early and rapid intervention and is originally inspired by the life support courses of severe trauma in the accident emergency department, which included two key elements- the early detection of deterioration coupled to a rapid response. Institute for Healthcare Improvement had recommended the Resuscitation teams as one of the main interventions in its '100,000 Lives Campaign' that was launched in 2005(10). Since then, thousands of RRTs have been instituted in North America and worldwide.

Brilli and colleagues(11) in a retrospective study implemented, a Medical Emergency Team (MET) with the aim to reduce the rate of cardio-respiratory arrests outside the Intensive care unit by at least 50% for a period of >6 months. The arrests that could be prevented were prospectively defined and the incidence of the codes before and after the institution of MET was looked into. There was no difference in the incidence of cardiopulmonary arrests before and after MET. For codes in the wards, the pre-MET mortality rate was 0.12 compared with 0.06 post-MET (risk ratio-0.48 with CI 0–1.4, p = .13). The overall mortality rate for outside the intensive care unit codes was 42% (15 of 36 patients). The study thus concluded that the implementation of a MET is

associated with a reduction in the risk of cardio respiratory arrest outside critical care areas in a tertiary children's hospital.

In a large retrospective analysis done by M.A.Devita etal,(12) 3269 MET responses and 1220 cardiopulmonary arrests over a period of 6.8 years showed an increase in MET responses from 13.7 to 25.8 per 1000 admissions (p,0.0001) after instituting specific activation criteria indigenously tabulated at Pittsburg University Medical centre. There was a 17% decrease of cardiopulmonary arrests incidence from 6.5 to 5.4 per 1000 admissions (p = 0.016).

In a recent study done by Christopher et al(13) Rapid response system implementation showed a 62% decrease in clinical deterioration comparative to the pre intervention (incidence rate ratio = 0.38; CI, 0.20-0.75). They had also observed absolute reductions in ward cardiac arrests (from 0.03 to 0.01 per 1000 non–intensive care patient-days). The deaths of ward emergencies decreased from 0.01 to 0.00 per 1000 non–intensive care patient-days. This warrants the clinical deterioration scales to be used for the inpatient emergencies. Among all unplanned transfers, critical deterioration was associated with a 4.97-fold increased risk of death (95% CI, 3.33-7.40; P < .001).

The median duration of clinical instability prior to the arrest was decreased from 9 h 55 min to 4 h 15 min post intervention (p = 0.028) in a study done by Hanson et al and Beitler et al.(13,14). Tibballs and Kinney reported that implementation of a paediatric

MET at The Royal Children's Hospital in Melbourne was associated with a 33% decrease in hospital mortality, a 67% decrease in unexpected hospital ward deaths, a 56% decrease in hospital ward preventable cardiac arrests and 91% decrease in deaths from preventable hospital ward cardiac arrests.

It is evident that implementation of a rapid response system brings emergency personnel to attend to Patients who are deteriorating earlier, hence preventing cardiac arrests. In a recent review of Eighteen studies from 17 publications (14) with nearly 1.3 million hospital admissions in children, RRT implementation was associated with a 37.7% reduction in rates of cardiopulmonary arrest outside the ICU (RR, 0.62; 95% CI, 0.46-0.84) and a 21.4% reduction in hospital mortality rates (RR, 0.79; 95% CI-0.63-0.98). The pooled mortality estimate in children was not large for sensitivity analyses.

Although RRTs/CARTs have broad appeal, robust evidence to support their effectiveness in reducing hospital mortality is lacking(17). These teams require trained personnel round the clock which is not feasible in many centres in India. The provision of pre emptive care relies on the timely identification of patients at risk and referral to the responding medical emergency team. In a cluster randomised trial of this medical emergency teams done in 23 Australian Hospitals, poor results were noticed which was a stepping stone for the evolution of yet another era for the patient safety with the introduction of scoring systems in the adults for the early recognition of deterioration(MERIT STUDY) (18).

Intervention after the cardiopulmonary arrest

The results of Cardio pulmonary resuscitation are influenced not only by the pre existing conditions before initiation of CPR but also by the resuscitation efforts. The causes of death after resuscitation include hypoxic damage in one third of cases, refractory myocardial damage, sepsis and other complications one third respectively. The ultimate goal of resuscitation is to improve survival with good neurological outcome.

In a large, multicentre, in-hospital cardiac arrest data base, done by Nadkarni et al,(1) the major cardiac rhythm was asystole, Pulse less electrical activity than the shock able rhythms of Ventricular tachycardia and ventricular fibrillation associated with progressive respiratory failure, circulatory shock, or both. Children survived to hospital discharge more frequently following cardiac arrest (73%, respectively of the arrests were discharged home) than adults did following asystole and PEA(24% in children compared to 11%in adults). It is worth that research could be done to prevent such events and the need for the early recognition is evident.

EARLY WARNING SCORES

Early warning scores are simple tools based on the bedside observations which record parameters like pulse rate, respiratory effort , blood pressure, temperature and level of consciousness etc. The fundamental assumption about their implementation is that the physiological processes underlying cardiopulmonary arrests are often treatable, and if the treatment is initiated before clinical deterioration they tend to have greater efficacy.

There are many early warning score developed by allocation of points to basic parameters, which cumulatively give a numerical value or score. The score provides an objective method of assessing the level of patient's sickness, in order to facilitate early intervention. Many adult scores are used for prediction of clinical deterioration which was mandatory in the western countries, for good clinical practice. Paediatric scores were developed based on adult scores.

The CART system greatly increases emergency team calling, but does not affect the incidence of cardiac arrest, unplanned ICU admissions and unexpected cardiac arrest and death. Similar issues in adult critical care resulted in the Department of Health recommending a hospital-wide approach to the identification and referral of critically ill adults (19). The Lancet had published the poor outcome of Cart systems (MERIT).This led to the development of critical care outreach teams in adult services and the original designs of a Paediatric Early Warning Score (PEWS) system, developed to provide a reproducible assessment of the paediatric patient's status based

on physiologic parameters by Monaghan in 2005(20)based on the adult scores .

Paediatric Early Warning Score

Paediatric Early Warning Score (PEWS) is a tool in which the vital signs or the condition of the patient is given a numerical value which is graded according to the intensity of variation from the normal .It helps in the recoding of the variation of each patient from normal in a short span of assessment, in a single sheet of paper. It can be graded and communicated to other health care professional easily. There are no contraindications and it can be modified based on the local conditions .Other parameters like surgery, cardiac parameters etc can be added.

The concept of PEWS

PEWS is a score which increases as the patient variables differ more than the normal values and is high when the child is critical. The scores can depict the severity of illness Patient B in Fig 1. Which and can be an indicator of deterioration

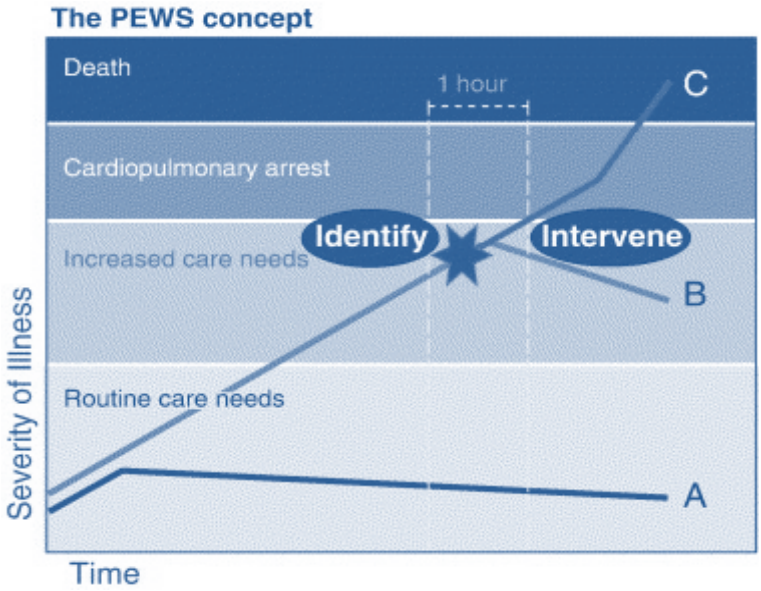


Fig 1.The mechanism of PEWS

predicting and the impending cardio respiratory collapse. Any intervention before the child declines with cardio respiratory arrest is useful in preventing any further down slide and saving lives (Patient C).

Multiple paediatric scoring systems have been developed worldwide, and Monaghan's PEWS is one of the most simple and flexible systems. It can be quickly performed, is not age specific, and has five domains: behaviour, cardiovascular status, respiratory status, nebulizer use, and persistent postsurgical vomiting. Monaghan's PEWS has been validated in retrospective studies of the inpatient floor setting of paediatric hospitals.

Table 2. The Brighton PEWS SCORE

mponents	0	1	2	3
haviour	Playing/ appropriate	Sleeping	Irritable	Lethargic/confuse or reduced respo to pain
rdiovascular	Pink or capillary refill 1–2 sec	Pale or capillary refill 3 sec	Gray or capillary refill 4secs or tachycardia of 20 above normal rate	Gray and mottled capillary refi seconds or above tachycardia of above nor rate or bradycardia
spiratory	Within normal parameters, no retractions	>10above normal parameters using accessory muscles or 30+ %FiO_2 or3+ L/min	>20 above normal parameters and retractions or 40% FiO_2 or6+ L/min	Five below-nor parameters with retractions grunting or 50%Fi or 8+ L/min

Score 2 extra for quarter hourly nebulizers or persistent vomiting following surgery.FiO_2 = fraction of inspired oxygen

PEWS are assigned in 3 domains: behaviour, respiratory, and cardiovascular. Scores in each domain can range from 0 to 3 points (Fig 1). In addition, 2 points are added for nebulisations that are continuous or every 15 minutes and 2 points for persistent postoperative vomiting. The total score can range from 0 to 13. The tool was further supported by an algorithmic response that is based on the score. There were four possible actions chosen by the nursing staff based on the calculated PEWS. These actions could be as simple as informing the charge nurse, increasing the observation frequency ,calling other colleagues for a review from the medical team initiating the MET. Monaghan also found that scoring a patient using the PEWS tool added 30 sec to the routine bedside assessment

TABLE 3.The development of various PEWS scores.

PEWS tool	Development
Brighton PEWS	Muti-disciplinary group discussions derived from the adult scores
Melbourne Activation Criteria	Expert Group, derived from the age derived normal values
PEWSSCORE System(Birmingham/Toronto)	Expert group utilising the Delphi approach for the consensus on the ranges and parameters.
PEW TOOL	Expert group; Derriford Hospital Plymoth, UK. Derived from criteria developed at Melbourne Children's Hospital, Australia.
Bedside PEW System Score	Expert group and statistical methods.
Cardiff and Vale PEW system	Based on the 2005 PALS Guidelines for the recognition of the sick children.
C-CHEWS	Expert group; based on the risk factors of a cardiaovascular patient

The PEWS system is very less cumbersome and reasonable tool to be incorporated into bedside clinicians' assessments. The use of early warning scores with adult patient populations has been associated with increased confidence among nurses and increased communication among healthcare provider in the event of an arrest.(21).

THE USE OF PEWS

The Paediatric Early Warning System (PEWS) score is useful for detection of deterioration in clinical condition. The initial outcome measure for the use of PEWS was to detect the sick children, however subsequently other outcomes had to be considered as the rate of arrests were less.

PEWS AS TRIGGER TOOL

O Loughlin(22) introduced the PEWS score as tool to aid in the identification of clinical deterioration and found out the triggering on the tool detected deterioration with a sensitivity of 100% and a specificity of 83%.

The PEWS has been used in a large prospective multicentre study done by Vandenberg et al(23) .The study showed that a score of 8 showed sensitivity and specificity of identifying the sick children to be 82% and 93%, respectively. The score increased over 24 hours preceding urgent paediatric intensive care unit (PICU) admission ($P < 0.0001$). In 436 urgent consultations, the Bedside PEWS score was higher in patients admitted to the ICU than patients who were not admitted ($P < 0.0001$).

In another prospective study done in Children's Hospitals of Minnesota(24) found that at least 87 % of the events in children could be identified early using PEWS score of more than 4(with a sensitivity of 84.2%) .

Tume .L. (25)examined observations of patients who were transferred to an increased level of care and found that PEWS identified 87% of these patients who were at risk for deterioration.

In a retrospective study done by Panesar(26) to examine changes in characteristics of CART calls before and after the use of PEWS as cues for the activation of CART. An elevated PEWS score of 5 was taken as the trigger. A total of 44 CART calls were recorded before mandatory triggering and 69 CARTs afterward in the study period (P = .32). Compared with the premandatory group, the mandatory triggering group found that tachycardia was highest trigger for RRTs, with an increase of 26.1% (P = .004). RRTs triggered by a dip in mental status/agitation decreased by 22.9% (P = .009). Mandatory triggering was not useful in 15.1% of CART calls requiring no interventions.

PEWS AS PREDICTOR TO TRANSFER TO PICU

In a retrospective case control study done by Skaletzky(26), the cases were patients who were transferred to the paediatric intensive care unit (PICU), and controls were those not transferred to the PICU. Mann–Whitney U test and receiver operating characteristic curve (ROC) were used to compare the two groups. The study population included 100 cases and 250 controls. The hospital stay days (18.09 ± 32 vs 3.93 ± 2.9 days; P < .001) were higher for the cases. The maximum PEWS score (2.95 ± 1.5 vs 1.4 ± 0.8) were significantly higher for the cases (P < .0001). The

PEWS score area under the ROC was 0.81 (CI 0.75-0.86). Thus the use of the PEWS score can help identify patients on wards who are at risk for deterioration.

Tucker et al(27) in a prospective study explained the sensitivity and specificity of PEWS for detecting clinical deterioration which resulted in unplanned transfer to the PICU. The study reported sensitivity of 84.2% at a score of 4 and concluded that PEWS could identify children who require transfer.

In a before-and-after observational study done by Sefton et al (28) with implementation of PEWs at the tertiary children's hospital about one year apart, the median Paediatric Index of Mortality (PIM2) reduced; 0.44 vs 0.60 ($p < 0.001$). Lesser admissions required invasive ventilation 62.7% vs 75.2% ($p = 0.015$) for a shorter median duration- four versus two days. The length of PICU stay decreased from five to three days ($p = 0.002$). There was a no significant reduction in mortality ($p = 0.47$) and no comparable improvement in outcome in emergency admissions to PICU.

The recognition of deterioration of in patients is necessary. In a modified Paediatric Early Warning Score (PEWS) studied by Joris, (29) by performing three different cohort studies using different end points, including unplanned Paediatric Intensive Care Unit admissions as end point as well as using data precisely 2 hour prior to end point, they noticed PEWS score was showing a sensitivity of 0.67 and specificity of 0.88 in timely recognition of sick patients. On using the need of emergency medical interventions as end point PEWS sensitivity is high and can predict the need for urgent interventions.

PEWS FOR ACTIVATION OF CART TEAM

Akre(30) used a modified different outcome measure and validated PEWS for the eventual code blue. It was found that the sensitivity of PEWS was 85.5%(the patient's had a critical score within 24 hours before the event) .The median time from the first value of high critical PEWS to an RRT code event was 696 minutes (11 hours, 36 minutes) and the latest critical score was 30 minutes for 159 (85.5%) of 186 patients. 73.1% of patients had a critical PEWS just before the RRT or code event . The median time from a critical PEWS just before the event was 30 minutes. A subgroup of the patients who received a medical consultation for the deterioration and the addition of a monitor were also evaluated .

In another study done by Duncan(31.32) , the ability of the score to discriminate between case and control patients was tested . Secondly, changes in the score over time were evaluated. The ability of scores to discriminate between case and control patients was assessed by logistic regression using the maximum score for the 24-hour period studied. At a threshold score of 5, the sensitivity and specificity were 78% and 95%, respectively.

A prospective, descriptive study done by Tucker,(33) by the tool was used to score 2,979 patients in a paediatric hospital over a 1 year period. PEWS discriminated between children who required transfer to the paediatric intensive care unit and those who did not require transfer (area under the curve = 0.89, 95% CI = 0.84–0.94, $p < .001$).

Table 4. PEWS STUDIES CHARACTERISTICS(An analysis)

Author	Objective	Study Design	Hospital	Pews tool used	Data collection, Analysis	Results
Duncan et al.	Development of bedside score to predict impending cardio respiratory arrest	Retrospective– Case control	Hospital for Sick Children Toronto	PEWS	Score ability to discriminate the cases and controls and changes In the score before the deterioration.	AUC was 0.90sensitivity -78% and specificity-95% at a thresh hold of 5.
Haines et al.	Identification of acutely ill children in the hospital wards with a clinical and physiological based tool.	Partly Prospective case control	Bristol Royal Hospital, UK	Bristol PEW	Documents checked for the vitals at deterioration Cases-360 Controls-180	Outcomes 1. Death 2.Resp/cardiac arrest 3.PICU transfer 4.Additional monitoring 5.No problems 100%sensitivity.

Monaghan	Developing PEWS for the detection of the children at risk.	Prospecti ve Cohort	Royal Alexandra Hospital Brighton.	Brighton PEWS	30 patients	PICU Transfer
Parashuram	Score to quantify the severity of illness in inpatient children	Case control	Hospital for Sick Children ,Toronto	Bedside PEWS	60 cases and 120 controls	Mean max scores-- cases-10.1 control-3.4 .AUROC-0.91 Sensitivity -82% Specificity -93% at 5.
Tibbals et al	To study the impact of MET team on the rate of cardiac arrest mortality and unplanned admission into PICU	Before and after study	Royal Children's Hospital, Melbourne	Paediatric MET Calling Criteria	Compariso n of retrospecti ve data with prospective data after MET team	The risk of cardiac arrest reduced to 0.114/1000 to 0.198/1000 admissions with the risk ratio of 2.22. The un expected death from 0.12 to 0.04 per 1000 admissions .

Edwards et al	To test the Melbourne criteria for the prediction of activation of MET	Cohort study	University Hospital, Wales	Cardiff and Vale PEWS	16 Children	Sensitivity =68.3% Specificity +=83.2% AUC=0.79
Fuijkschot et al	Validation of PEWS	3 cohort studies	Radboudu mc Amelia Children's Hospital, Netherland s	Bedside PEWS	119 patients but no cardio respiratory arrests	PEWS >8 Can predict the unplanned PICU admission by 2-6 hours.
Akre	To find the sensitivity of PEWS. Hypothesis -80% would have a critical PEWS 4 and above.	Retrospec tive chart review.	Children's Hospital, Minnesota	PEWS by Monagha nan	Demograp hic details taken into considerati on. 170 RRT calls and 16 code blue calls.	Sensitivity =85.5%

Sharek et al	Evaluating the effect of RRT implementation on the inpatient mortality	Cohort study with historical controls	Lucile Packard Children's Hospital	Paediatric RRT Triggering criteria 1.1staff concern 2.acute respirator rate increase 3.change in oxygen saturation 4.acaute change in heart rate 5.blood pressure 6. level of consciousness.	Children in the pre-intervention and post intervention period are compared	The code rate was 0.29 times that of the pre intervention group.
Zenfer et al	To study the effectiveness and the impact of implementing the RRT concept	Pre and post implementation	Children's Hospital Minnesota	Paediatric Rapid Response Team	150 activations studied	Mortality rate was the same but the incidence of arrests decreased from 8 to 5.1 per 1000 admissions.

Bell et al	To examine the Psychometric properties of the TCH PAWS.	Retrospective chart review.	Texas Children's Hospital	Paediatric advanced Warning Score(PAWS)	150 infants and children	Score above 5 resulted in 80% of RRT calls.
McLellan etal	To validate Cardiac Children's Early warning Score(C-CHEWS)	Retrospective cohort study	Cardiovascular Unit, Children's Hospital	CCHEWS and PEWS	Comparison of the scores for the deteriorati on	Outcome-Cardiopulmonary arrest,Unplanned admission to ICU.C-CHEWS is better than PEWS
Robson et al	To validate various PEWS tools	Retrospective cohort Case=controls=96	ICU setting USA	PEWS,PEW Tool	Comparison of the scores for the deteriorati on	Based on AUROC, Duncan score is better than PEWS tool and Bedside PEWS.
Sefton et al	The validation of PEWS to predict emergency admission to PICU.	Before and After cohort study	Alderhey Children's Hospital	Modified Bristol PEWS	PIM2 score was done at admission	Median PIM2 score dropped to from 0.60 to 0.44.

Skaletzky	To validate PEWS in the less acute areas of care.	Case control study	Miami Children's Hospital	Modified Brighton score	Data collected before 48 hours of admission to PICU.	Outcomes- Code blue, RRT and PICU transfer.
Lobos et al	To explore triggers for the hospital care staff for activating MET	Retrospective cohort study	Paediatric Tertiary Hospital Ontario	Rapid Response System		1.Physicians had a higher MET activation than the nurse led teams. 2.In the total 458 MET activations, 86had surgery in the past 7 days. 3.The triggers were respiratory (48.5),circulatory(18.1%),neurologic (16.3)% and others(34.1%).

Brilli et al	Study to assess the effectiveness of MET and to develop Trigger tool to reduce the codes by 50/5 outside the ICU following implementation	Retrospective chart review	Children's Hospital ,USA	MET Activation Criteria	Survey and Staff performance assessments	1. 25 MET codes compared to 6 in the post MET period. 2.Code rate decreased from 1.54 to 0.62.
Tucker et al	Validate PEWS	Prospective descriptive study	Cincinnati Children's Hospital	Monaghan PEWS	Tools to be completed at every shift by the staff nurse Total no. of Participants-2979.	Outcomes-Transfer to PICU AUROC of the score was 0.89 with good association.
Tume et al	To estimate the inpatient deterioration	Prospective Chart review	Specialist Children Hospital ,UK	Bristol PEWS, Melbourne PEW	Comparison of the two scores. Sample size-65 unplanned admissions	The Bristol Score scored well with the ICU shift-in but the Melbourne score fared well for children admitted in HDU.

Hansen et al	Study to assess the effects of Multi faceted Paediatric Rapid Response System on the duration of predefined clinical instability and the rate of cardiac arrests	Retrospective chart review	Univ. Affiliated Paediatric Hospital. USA	Paediatric RRT	Analysis of the before and after rates.	1.Significant increase in the mean time between the cardiac arrest from a baseline level of 2512 to 9418 . Decrease in the mean duration of clinical instability from9 hr55min to 4 hr15 min in unplanned PICU admissions Ward cardiac arrests decreased from 1.27 per 1000 to 0.45 per 1000. Ward death per ward 1000 admissions also decreased from 1.5 to 0.45

Author	Object	Design	Hospital	PEWS tool	Analysis	Outcome
Haque et al	To study to report the before and after implementation of Paediatric Rapid Response Team in Paediatric Wards to determine the effect and outcome of intervention	Retrospective audit	Agha Khan Tertiary care University Hospital	Paediatric RRT	Codes and MET intervention	83 calls assessed. Mortality rate decreased from 50%to 15% with decrease in intubation rate.
Zhai et al	To develop automated algorithm to predict the need for PICU in the first 24 hrs of admission.	Retrospective case control study	Cincinnati Children's Hospital	Manoghan Tool and Bedside Tool	526 cases and 6772 controls	The algorithm had 0.912 AUC .
Hunt et al	To know the effect of intervention to prevent cardio respiratory arrest	Before and after trail intervention	John Hopkins Children's Hospital.	Paediatric Medical Emergency Team	Analysis of rate of cardio respiratory arrests ,survival post arrest	Incidence of respiratory arrests decreased by 73%../

Author	Object	Design	Hospital	PEWS tool	Analysis	Outcome
Kotsakis et al	To study the effectiveness of paediatric rapid response system(PRRS)	Multi centre, prospective observational study design	Hospital for sick Children, Toronto.	Physician led MET	Data collection tools and data base developed by the expert group	1.The rate of code blue events came down to 3from 4(RRR=0.71) 2.The rate of PICU readmission was significantly reduced. 3. Mortality rate decreased (RRR-0.43).
Mc Crorey et al	To evaluate the introduction of simulation for teaching Paediatric interns	Prospective pre and post intervention study	John Hopkins simulation centre	Mock simulation and response to the vital signs	52 interventions were analysed	Start off time and the recognition of sick child increased but the mortality was the same
Rolannd et al	The prevalence ,characters and opinions of RRT in various Hospitals	Cross sectional survey	All hospitals	Questionnaire	126 district general Hospitals	Respiratory and heart rate were two commonest criteria for the activation of RRT

Panesar et al	To study the RRT calls before and after the mandatory triggering based on high PEWS	Retrospective review of RRT data base	Stony Brook Long Island Children's Hospital;	Paediatric RRT+PEWS SCORE	40children in the pre - mandatory group and 63 in the mandatory triggering group if the PEWS is more than 5.	RRT calls in the post automation group required fewer respiratory interventions with decrease of 24% in the use of supplemental oxygen and by 11.6% for bag and mask ventilation.
Avent et al	To show the use of a Rapid Response team in the management of severely septic patient	Case Report	Paediatric Oncology Outpatient Department. St. Jude Children's Hospital ,Memphis	Paediatric Rapid Response team	16 cases	RRT helped in obtaining further clinical evaluation quickly which helps in earlier intervention and improves outcome.

Author	Object	Study	Hospital	Score Used	Analysis	Outcomes
Bonafide et al	To assess the impact of paediatric Rapid Response System Implementation which included a Medical Emergency Team and an Early Warning Score upon Critical Deterioration?	Retrospective analysis of charts	Children's Hospital, Philadelphia	The RRT included a medical emergency Team and Bed side Early warning score	Evaluation of 1810 unplanned transfers to PICU	1.No significant reduction in the cardiac arrests and deaths. 2.Ward Cardiac Arrests decreased from 0.03 to 0.01 per1000 and deaths reduced from 0.01 to 0.00 per 1000 non intensive care patient days. 3.Higher incidence of ICU transfer during the post implementation period. 4.Derioration rate 1.52per 1000ICU patient days-8 times common than the non ICU days 5.Specificity was 98.8%with PPV-41.7% and NPV-96.5%

PEWS IN THE ADOLESCENCE

In a study done in Norwegian children, Solevag et al(31), modified the Brighton PEWS score done at Oslo University in a retrospective Chart review. They found that the score of ≥3 was associated with severe illness, proving it is a good tool for the early risk prediction. A total of 761 patients (0−18 years of age) were included in the analysis. A younger age and diagnostic groups such as lower airway and cardiovascular disease were associated with PEWS ≥3. Upper airway disease and minor injury were more frequent in patients with PEWS 0−2. Children with PEWS ≥3 received fluid resuscitation, intravenous antibiotics, and oxygen supplementation, and were transferred to a higher level of care more often than children with PEWS 0−2.

THE MODIFICATIONS OF PEWS

Duncan et al (43) had developed a 20 item early warning score (PEWS) at the Children's Hospital, Brighton, England. It has 5 domains- behaviour, cardiovascular status, nebulizer use and persistent postsurgical vomiting. Parashuram (44) had modified the score with seven items in the Bedside PEWS score which were heart rate, systolic blood pressure, CRT, respiratory rate, respiratory effort, trans cutaneous oxygen saturation and oxygen therapy. The Bedside PEWS score could identify more than 80% of patients who required emergency admission into PICU with at least one hour notice. A score of 8 offers the best combination of sensitivity and specificity, and provides a statistical basis for recommending a threshold for ICU admission.

The original PEWS score was adapted by Quist-Therein Hertfordshire NHS trust Hospital (45) using colours as indicators of deterioration which became very popular and easy to use predictive tool.

A modified paediatric early warning (PEW) tool was designed by Solevag (46)based on all children (n = 360) who triggered the tool over a 6-month period and the analysis of the data was undertaken on each criterion within the tool .This modified tool showed a 99% sensitivity and a 66% specificity for use in a tertiary children's hospital in the United Kingdom (UK). Numerous scoring systems have been introduced with varying levels of complexity based on the score like the Bristol, Brighton, Alder hay and BCH.(47). There are numerous versions of the PEWS score being used in UK.

More recently, Burton PEWS which included nine parameters was also validated by Ahmed etal and found to be effective in identifying children at risk of sudden deterioration .(48) In a study done by Robson, the predictability of three previously validated PEW scoring tools was compared. This was a retrospective case-control design that identified the PEW System Score as a stronger predictor of cardiopulmonary arrest (CPA) than either the PEW Tool or the Bedside PEW System Score. The PEW System Score demonstrated a greater sensitivity (86.6%) and specificity (72.9%) at a score of five.

PEWS IN THE EMERGENCY DEPARTMENT

Emergency services cater to the need of sick children and they can have prolonged periods of waiting time on a busy day either for discharge or admission into the wards. These children can deteriorate if not monitored for the subtle physiological change. PEWS score takes these variables and is a tool for the prediction of the admission needed either to ICU or to the wards. In a study done by Gold, (49) PEWS was implemented in paediatric Emergency Department with excellent data capture and inter -rater reliability. The study found that high PEWS score is associated with ICU admission directly from the ED and as a transfer, but lacks the necessary test characteristics to be used independently in the ED environment.

As the waiting time for the patients who visit the emergency department is long, Bradman et al (50) designed a study to view whether the PEWS score could be useful as a triage tool to detect those patients who will need admission. PEWS score of >+4 had a sensitivity of 24% and low specificity. At the same time if the score was 2 patient never needed admission.

In a study done by Breslin (51), the association between the PEWS and the Emergency department disposition was looked into. It was observed that one point increase in PEWS increased the odds of ICU care by 2.09 relative to discharge and by 1.40 relative to acute care. PEWS score of 3 demonstrated 31% sensitivity and 91%specificity for admission while a score of 5 had 28%sensitivity and 96%specificity for admission.

In a study done at Thailand (52) validated a study after the initial trail for blinding the inter rated variability at Ramathibodi Hospital and involved 1136 patients. Validity of the scoring system for predicting admission was assessed using area under the receiver operating characteristics (ROC) curve (AUC), sensitivity, and specificity, positive predictive value (PPV) and negative predictive value (NPV). Predictability for the overall ICU and general ward admissions were 0.98 (95%CI: 0.96–1) and 0.71 (95%CI: 0.66–0.75), respectively. The sensitivity and specificity in predicting overall admission with a cut-off of PEWS ≥1 was 78% and 60%, respectively (PPV, 28%; NPV, 95%). Sensitivity and specificity of PEWS in predicting ICU admission with the cut-off ≥3 was 100% and 91%, respectively (PPV, 5%; NPV, 100%). Using the cut-off PEWS ≥1, sensitivity and specificity in predicting ward admission were 77% and 59%, respectively (PPV, 24%; NPV, 94%).PEWS can help in assessing status in paediatric ED with acceptable validity and can serve as a potentially excellent screening tool for prediction of ICU admission.

In a large cohort study done by Seiger N (53), Ten different PEWS were evaluated in Emergency and found that among 17943 children, the area under the ROC predicting the ICU admission is 0.82(CI 95%:0.79-0.85).The study concluded that PEWS can detect children presenting to the emergency department who are in need of ICU care .

It was also been found by O loughlin Kin et al(54), that PEWS can predict the effectiveness of intervention done at emergency department.

OTHER SCORES USED IN EMERGENCY

There are few studies in children which have been done in the emergency department unlike the adults. A few scores that are used are the Manchester PEWS,SOFA,POPS ,PAWS and the PEWS.

Egdell devised a physiology-based scoring system for assessment of children presenting to the emergency department (ED) and to validate the system retrospectively. Age-dependent physiological parameters to reflect the cardiovascular, respiratory and neurological status of patients presenting to the ED were included in a scoring system called the Paediatric Advanced Warning Score (PAWS). A retrospective pilot evaluation was performed to validate PAWS. The PAWS score area under the receiver operating characteristic curve was 0.86. Using a trigger score of 3 or above, PAWS was able to identify patients requiring PICU admission with a sensitivity of 70% and a specificity of 90%. More studies are needed with this score as it was done in only 49 patients and done retrospectively.

The Paediatric Observation Priority Score (POPS) is an Emergency Department (ED) physiological and observational aggregate scoring system, with scores of ranging from 0–18. A higher score indicates greater likelihood of admission. The Manchester Children's Early Warning System (ManChEWS) assesses six physiological observations to create a trigger score, stratified in levels as Green, Amber or Red.

In a prospective study comparing POPS and ManChEWS (55)on 2068 patients aged less than 16 years of age in one month to a UK District General Hospital Paediatric

Emergency Department(ED), to predict admission to hospital within 72 h of presentation to the ED. Comparison of the area under the Receiver Operating Characteristics (ROC) curve indicates that the Man ChEWS ROC was 0.67 (95% CI 0.65 to 0.70), SE 0.02, and the POPS ROC was 0.72 (95% CI 0.69 to 0.75), SE 0.02. The difference was statistically significant ($p < 0.01$). At a POPS cut-off of ≥2, 80% of patients had their admission risk -Positive Predictive Value (PPV) of POPS 2, 38.94% whereas for Man ChEWS with a cut off of ≥Amber colour ,only 71% of patients were correctly classified (PPV of Man ChEWS Amber, 29.06%). Hence POPS proved to be a more accurate predictor of admission risk from the ED than Man ChEWS and was more suitable to use in an ED setting. Replacing Man ChEWS with POPS .

In a study done by Sweney et al(56),PEWS was compared to other paediatric triage tools like M-SOFA(Modified Sequential Organ Failure Assessment Score),The Paediatric Risk of Admission Score II(PRISA-II) with Physician clinical Judgement. There was no significant difference between the scores to predict the ICU admission however all the scores were equally inferior to the best Physicians assessment. POPS (Paediatric Observation Priority Score) is a novel scoring system used for the likelihood of admission to the wards and also for the discharge(29).

In a systematic review done by Chapman et al(57), studies are needed for determining the physiological parameters or combination of parameters which could best predict serious adverse events.

Table 5 .Study characteristics done in Emergency Department

Author	Purpose	Design	Hospital	PEWS	Analysis	Outcomes
Bradman and Maconochie	To identify if PEWS can be used as a tool to detect patients who need hospital admission	AUDIT	St.Mary's Hospital London.	Brighton PEWS	Score done for all the patients and then evaluated	PEWS score of >4 had a sensitivity of 24%,specificity of 96%.So it cannot predict the admission but if the score is high, admission was not needed.
Breslin et al	To study the association between PEWS at disposition from Emergency and admission	Prospective observational study	Emergency Department	Brighton PEWS	PEWS score	Score of 3 or more had maximum discriminating ability to distinguish admission from discharge with a sensitivity of 60% and specificity of 83%

Seiger et al	To validate a score for the initial assessment of children presenting to emergency department.	Prospective cohort study	Sophia Children's Hospital	10 different version of PEWS	Scores calculate in 10 tools and compared	The scores were not both specific and sensitivity. The score was predictive of ICU admission but not admission.
Egdell et al	To validate a score for the emergency department	Retrospective study	James Cook University Hospital	Paediatric Advanced Warning Score(PAWS)	PAWS score compared between two groups	The mean and median of the score was higher in children admitted to ICU than in the wards

The use of PEWS has increased since 2005 as studied by D.Roland et al(42). The implementation has been inconsistent with large variation in the PEWS used; Hence there must be a coordinated evaluation for standardization of PEWS score ,in various settings where acutely sick children are managed.

THE LIMITATIONS OF PEWS

1. PEWS scoring system have been validated in many centres at a point of time in tertiary care teaching hospital in their paediatric wards, however it has not been analysed in India or the District Hospitals, where the patient population could vary.

2.These scores were developed by experts and multidisciplinary working groups but there is very less similarity and consistency in the scores . Hence the cut off points, calling criteria and measurements of the score values vary greatly.

3.There is no similarity in the reference ranges in the scores used in all the studies.

4.The diversities in the published data does not help in the comparisons between the evidence, optimal score values .

5.PEWS have not been used extensively in the newborn period and hence it leaves out the major cause of death in India to pass through deterioration under the nose.

6.There is a lack of economic implications that can be averted by using PEWS as a trigger for detecting any deterioration in the children.

There is a paucity of scoring systems and studies done on PEWS in India. All the studies done have developed a de novo score from the data sets with little reference to the original score. We intend to develop a prediction score to assess the sickness of the child presenting to the emergency department and their chance of deterioration within 48 hours of admission.

MATERIALS

&

METHODS

METHODS

Setting & Study Period:

This is a prospective observational study done in Paediatric Emergency Service (PES) and in the Pediatric wards, Christian Medical College, Vellore for a period of four months from February 1, 2015 till May 31, 2015.

Development of PACS scores:

Paediatric Acute Care Score (PACS) was developed from the standard validated Paediatric Early Warning Score (PEWS), (Table 6) which includes parameters of routine clinical examination. The variables were selected and relevant co-morbid factors were added as per the opinion of an expert panel consists of our Paediatric Intensivists, Paediatric Emergency Physician, emergency nurses and critical care therapists. The variables were given alphabetical nominal and not numerical values to avoid bias.

Table 6. Pediatric Acute Care Score (PACS)

	A	B	C	D
Behaviour	Lethargic or confused or reduced pain response	Irritable and unconsable or Parents concerned	Sleeping or irritable and consolable	Playing appropriate
Cardiovascular	Grey or cyanotic & mottled or CRT > 5 Secs or Tachycardia 30 above or bradycardia for age	Grey or Cyanotic or CRT >4 secs OR Tachycardia 20 above normal parameters	Pale or dusky or CRT 3 sec	Pink or CRT 1- sec
Respiratory	> 30 above or > 5 below normal with retractions or tracheal tug or grunting or >50 %Fio2 or 8 ltr/min O2	>20 above normal or using accessory muscles or 40-49% %Fio2 or >6 lit/min O2	>10above normal parameters Or Using accessory muscles or 30 -39%% Fio2 or >3 lit/min O2	Within norm parameters f age , N recessions

The original Brighton score was used as the standardised early warning score in the study. The vital signs used for different age groups of children were also provided in the same sheet of paper according to the standard reference ranges (Table 7).

Table 7.The standard reference of the vitals varying with age (PALS 2011)

Age	Heart rate(per min)	Respiratoryrate(per min)
1-12months	100-180	35-40
13 months – 3years	70-110	25-30
4-6 years	70-110	21-23
7-12 years	70-110	19-21
13-19 years	55-90	16-18

The co morbidities generally seen in our centre were ascertained score of A or B (Table 8) for compensated and decompensate state respectively.

Table 8.The co morbidities included in the study

Pathology	A	B
Oncology	Neutropenic	Non-neutropenic
Chronic pulmonary pathology	Present	Absent
Chronic Cardiac pathology: CHD/Cardiomyopathy	Compensated	De-compensated
Chronic renal pathology	Present	Absent
Immunodeficiency state	Present	Absent

Inclusion criteria-

Children with ages between 28 days to completed 15 years presenting to Pediatric Emergency Service (PES), who require admission to paediatric wards.

Exclusion criteria

1. Children who require direct admission to Paediatric intensive care unit (PICU) at the time of presentation to PES, as per the treating physician's opinion.

2. Children admitted to semi-ICU cubicle in the Q5 South ward due to lack of beds in the PICU

3. If the difference between the time of presentation (T0) and the time at which admission was decided (T1) is more than 24 hours.

Methodology:

The study was conducted in the Paediatric Emergency Service (PES) and the paediatric wards of Christian Medical College, Vellore. All children (aged between 28 days of life to completed 15 years), presenting to PES, who required admission to the paediatric wards were enrolled into the study after obtaining a written informed consent from the parents. The enrolled participants were assessed by the physician (Casualty Medical Officer/Senior Registrars) and their demographic details, primary diagnosis, co-morbid factors and Pediatric Acute Care Score (PACS at T0)) were documented in a standardized proforma. The children who needed direct admission to ICU as per the Consultant/Senior Registrar's (Paediatricians, Paediatric Emergency physician or Paediatric Intensivists) opinion and those children who required intensive

care but admitted to the Semi-ICU cubicle at Q5 South ward due to lack of bed in Paediatric ICU were excluded from the study.

The assessment (PACS) was done twice (i.e.) at the time of presentation to the PES (T0) and at the time when admission to the ward was decided by the Consultant/Senior Registrar (T1). In some patients, the decision of admission was made at the time of presentation to the PES and for them T0 is same as T1. But in others, the decision of admission was made later (minutes to few hours) after the presentation to the PES based on the clinical status and lab parameters. If the decision of admission was made 24 hours after the presentation to the PES (i.e., if the difference between the T0 and T1 is more than 24 hours), then the participant was excluded from the study. Each participant child was followed up for 48 hours after admission to the paediatric wards. If the children who are admitted in the ward had deteriorated, then the score and the time of deterioration (Td) were also noted. The children who were discharged well from the causality and the wards were not included in the analysis.

The primary outcome is "**clinical deterioration requiring ICU or HDU care"** which is defined as,

1. Cardio-pulmonary arrest

2. Respiratory failure requiring intubation

3. Worsening respiratory distress leading to respiratory support in the form of

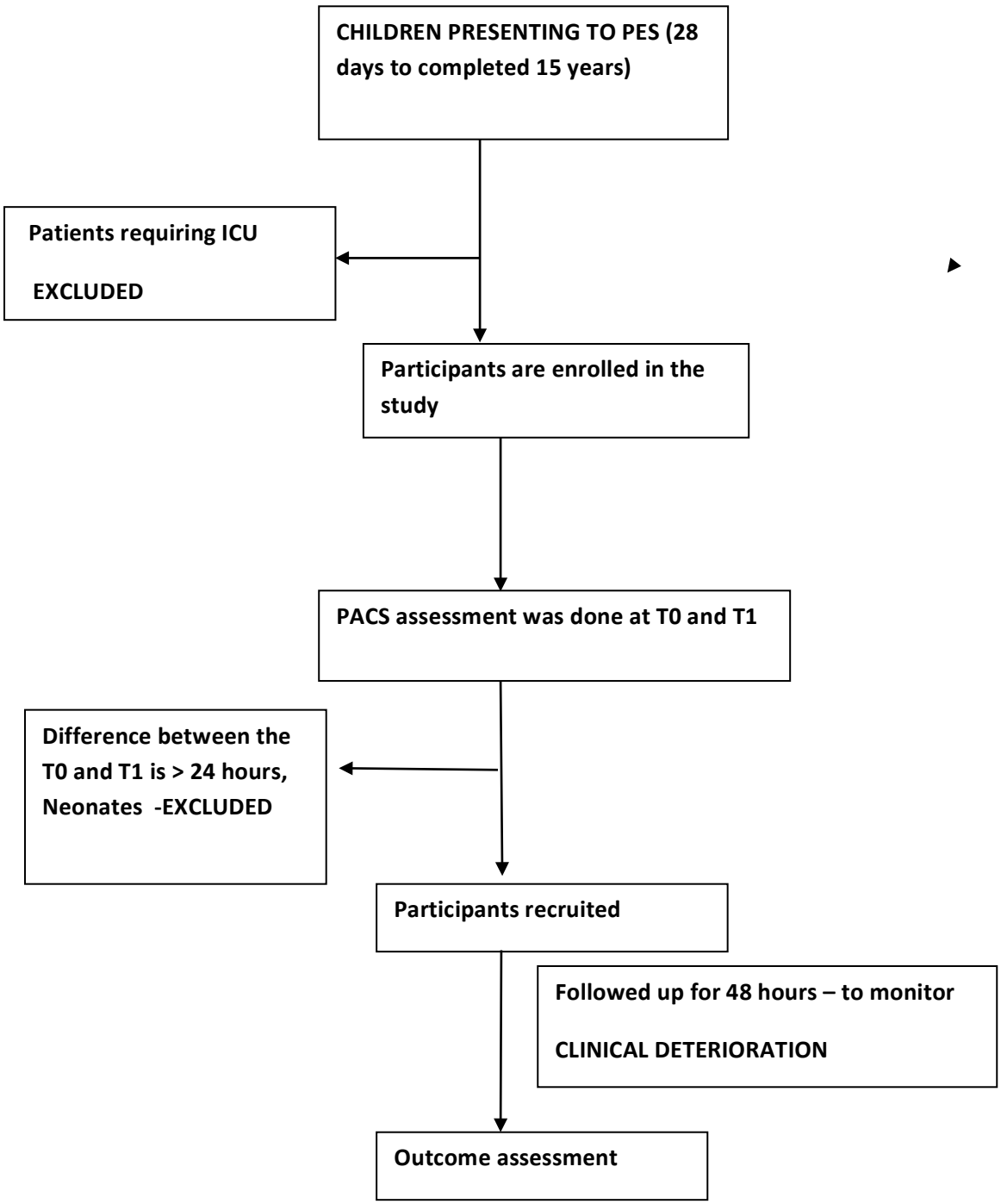
Non-invasive ventilation or high flow oxygen therapy.

4. Worsening of shock requiring > 10 mcg/kg/min Dopamine and or addition of a Catecholamine / vasopressin and or increasing lactate level of more than 2 from the baseline / metabolic acidosis.

5. Deterioration of sensorium –i.e. drop in Glasgow Coma Scale (GCS) >/= 2 since admission to the ward

6. Persistent, uncontrolled seizures after two long acting anticonvulsants, requiring continuous anticonvulsant infusion.

Fig 2.The Flow diagram for the methodology of the study



Predictors:

We hypothesized that PACS done at the time of presentation to the PES (T0) and at the time when admission was decided (T1), can predict the clinical deterioration early.

Bias:

The casualty medical officer (CMO)/ Senior registrars who collected the details of the patient and do PACS assessment were unaware of the outcome. The PACS assessment was done in the form of alphabetical variables instead of numerical variables and the treating physician and the investigators were unaware of the score. The principal investigator has followed the participants and assessed the outcome. The chance of bias was negligible.

Sample size:

The sample size was calculated from the already validated original study and the modification of the original study which was done for the admitted children .The significant use of the score was noticed without fail in the study.

A sample of size 78 was required to detect an on odds ratio of 2.8 times with the PEWS score of 8 and above requiring ICU admission in children with clinical deterioration with 80% power and 5% level of significance. Using a pilot data, done for 10 days, we came to the assumption that the proportion of ICU admission among the normal admissions was 45%. As the number of children who presented to Paediatric Emergency in the four months period slightly exceeded the initial sample

size calculated. A total of 101 patients had clinically defined deterioration during the study period.

Statistical Method:

The data was entered in Epidata version 3.1 and analyzed with STATA .The scores were plot in the Receiver Operative Curve (ROC) and the Area under the Curve (AUC) was calculated to look at the individual specificity, sensitivity, positive predictive Value and Negative predictive value. The Odds ratio and Likelihood ratio also was calculated .The Logistic regression analysis and Pearson square test was used to study the relationship between ICU admission and the PACS score and the time to deteriorate. The demographic variables were compared using the Pearson Chi-square test.

RESULTS

RESULTS

Our study was done in Pediatric Emergency Service (PES) for a period of four months- 1st February 2015 till 31st May 2015. The neonates (<28days of age) and the critically ill children who needed PICU admission directly from PES were excluded from the study. The demographic details and the PAC score (PACS) was calculated for all the children at the time of presentation to PES (T0) and the time when the decision of admitting the patient in the ward was made (T1) by the consultant.

There were total of 7,646 patients presented to the PES during our study period. Among this, 660 children required admission as decided by the treating physician. We have excluded the patients who were admitted late to the wards after 24 hours of 'admission decision' was made (100 children). The remaining 560 patients who have been admitted within 24 hours of presentation to PES were recruited in our study (Fig-3). The outcome was assessed for all the 560 patients. The demographic details of the patients are described in the Table 9.

Fig 3.THE FLOW DIAGRAM OF THE STUDY

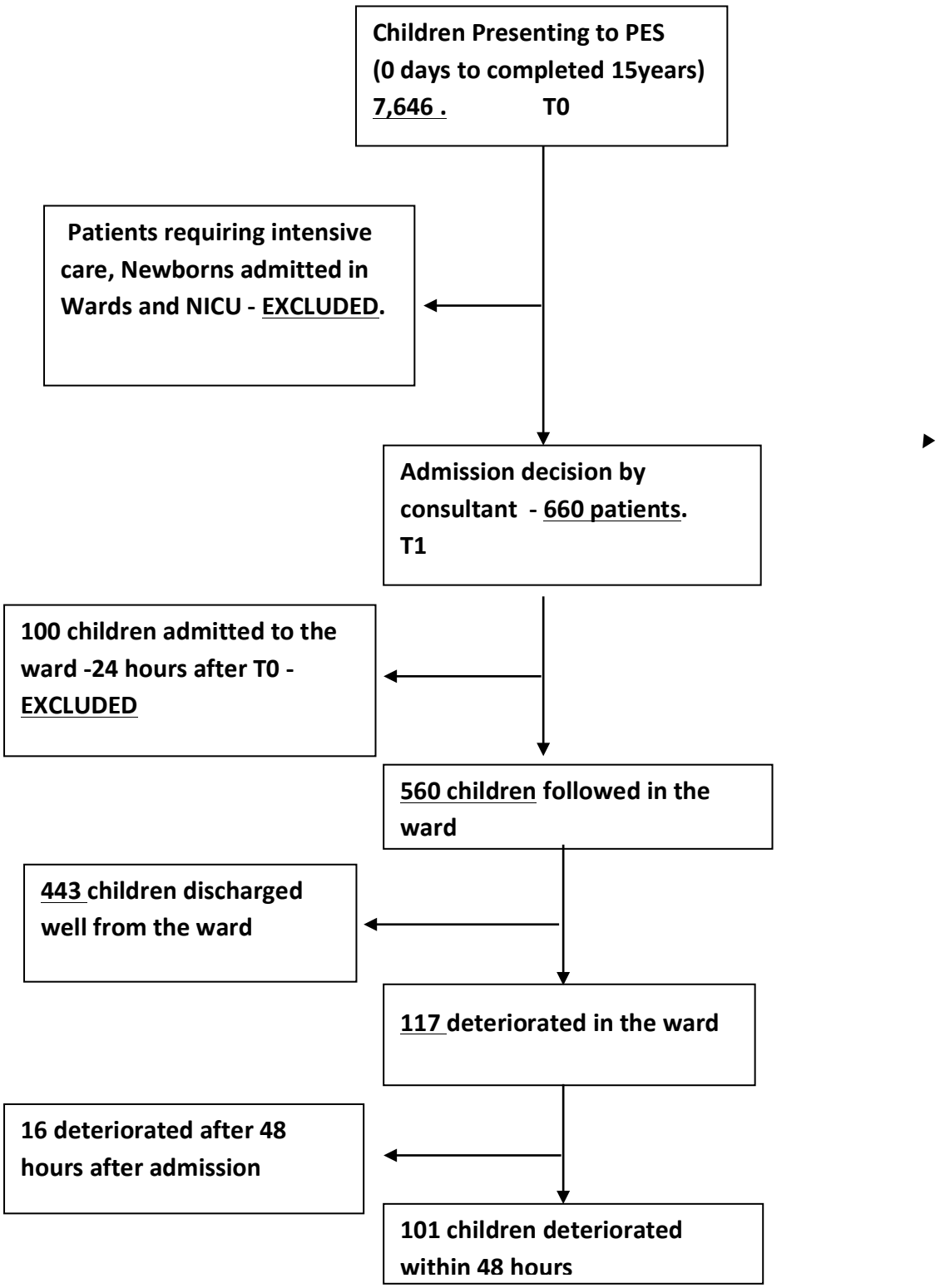


Table 9..DEMOGRAPHIC DETAILS OF THE PATIENTS

AGE (yrs)	Non deteriorated Patients N (%)	Deteriorated patients N (%)	Total(%)	PearsonChi^2	P value
<1	190(77.86)	54(22.13)	244(100)		
1-5	140(82.35)	34(17.65)	174(100)		
5-10	57(78.08)	16(21.92)	73(100)		
>10	56(81.16)	13(18.43)	69(100)		
Total	443(79.10)	117(20.89)	560(100)	0.96	0.8
Gender of the child					
Male	255(78.46)	71(21.53)	325(100)		
Female	188(80)	46(20)	235(100)		
Total	443	117	560	0.4028	0.526

Age and Gender distribution:

The mean age of patients in our group was 3.9 years . Among the 560 children, 244(43%) were infants, 173(30%) were 1-5 yrs of age , 79 (15%)were 5-10 yrs of age and 64 (12%)were >10 yrs of age.(Fig-2). In our study group, 325(58%) children were male (among which 71 deteriorated) and 235(42%) were females(among which 46 deteriorated.

AGE distribution vs Clinical Deterioration

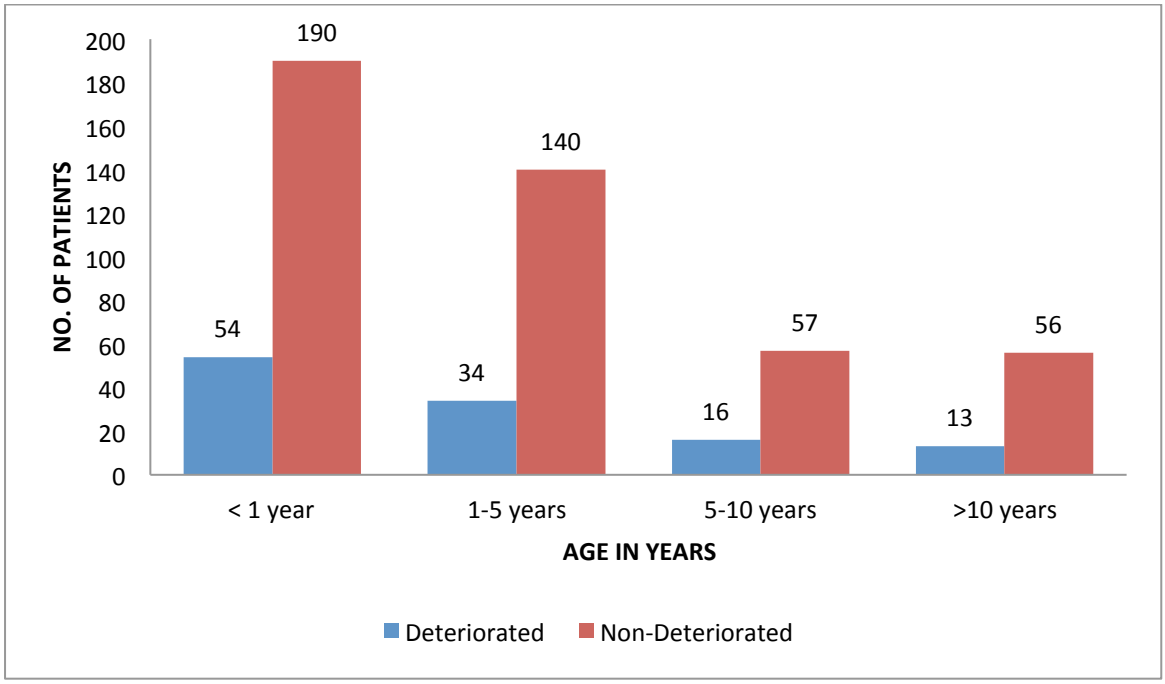


Fig 4.AGE distribution vs Clinical Deterioration

The mean age of patients in our group was 3.89 years with standard deviation of 4.21 (0.10- 18.00).The median (inter quartile)age was 2 years (1,6).Among the 560 children, 244(43%) were infants, 173(30%) were 1-5 yrs of age , 79 (15%)were 5-10 yrs of age and 64 (12%)were >10 yrs of age (Fig-2). Among the 244 infants, 54 (22%) deteriorated compared to children >10 years, in which 18 % (13 out of 56 children) deteriorated. Among the hospitalised children, 20 % i.e., one out of five admission deteriorated after admission, across all the age group. There is no statistical difference between the 'Clinically Deteriorated' and 'non-Deteriorated' group with respect to age distribution(p-0.8).

GENDER vs Clinical Deterioration:

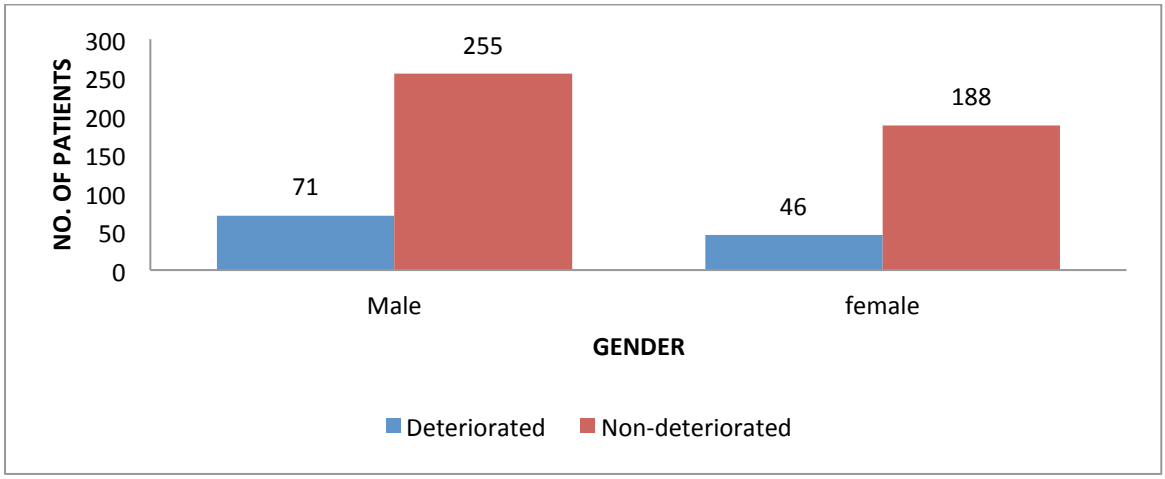


Fig 5.**GENDER distribution Vs PAC score**

In our study group 325(58%) children were male (among which 71 deteriorated) and 235(42%) were females(among which 46 deteriorated). There is no statistical difference between the 'Clinically Deteriorated' and 'non-Deteriorated' group with respect to gender distribution(p-0.56), (Fig-5).

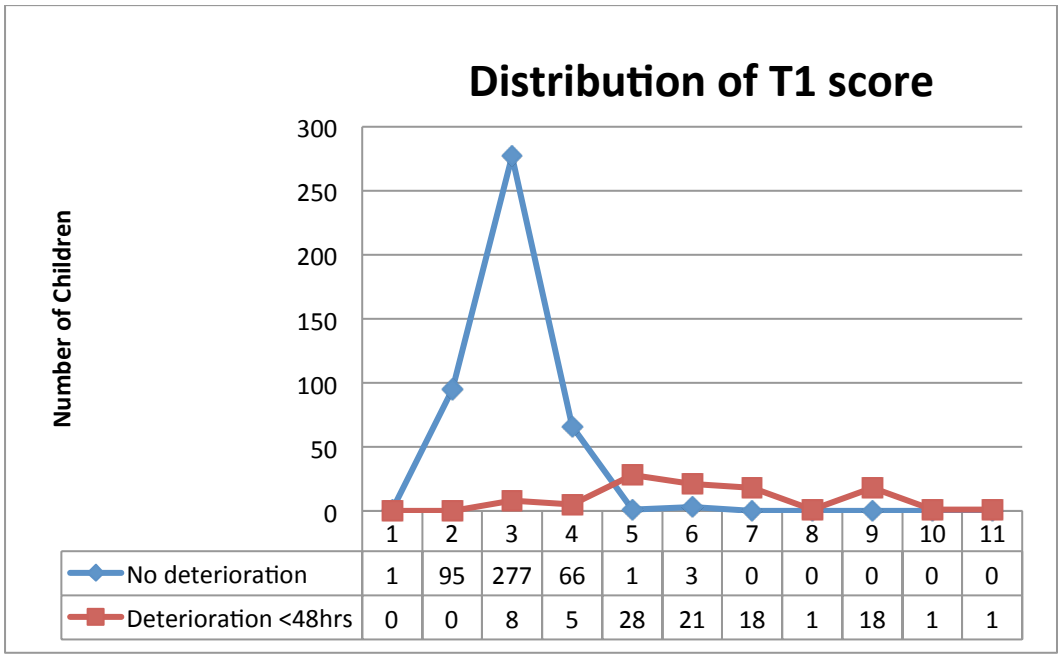
PAC-Score in the study

The PAC score (T1)at the time of admission and the corresponding outcome are tabulated in Table-10. Among the 560 children who required admission, 290 children had a T1 of 2 , 100 children had T1 of 1 and 39 children had T1 of $\geq$6. All the 39 children who had T1 of $\geq$ 6, deteriorated within 48 hours of admission. Among 55 children who had score of 4 and 5, 49(89%) deteriorated within 48 hours of admission (Table-10) .

Table.10:The distribution of the PACS scores(T1)

PACS (T1)	No deterioration(n)	Deterioration <48hrs (n)	Deterioration after 48hrs(n)	Total(n)
0	1	0	0	1
1	95	0	5	100
2	277	8	5	290
3	66	5	4	75
4	1	28	0	29
5	3	21	2	26
6	0	18	0	18
7	0	1	0	1
8	0	18	0	18
9	0	1	0	1
10	0	1	0	1
Total	443	101	16	560

Fig 6.The distribution of the PACS score at the time of 'admission decision'(T1)



Clinical Deterioration vs Non-Deterioration

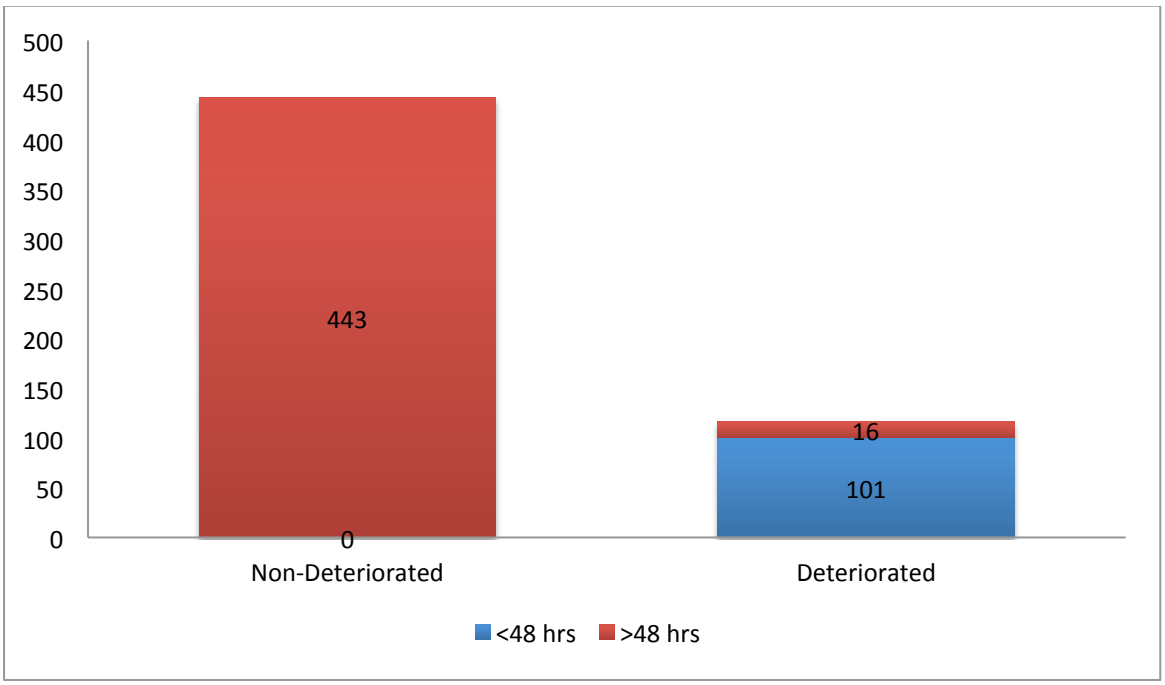


Fig -7: Deteriorated vs Non-Deteriorated in the study

Among the 560 patients who are admitted, 443 (80%) were discharged after complete recovery. The remaining 117(20%) children deteriorated during the course of hospital stay. Among which 101(87%) children deteriorated within 48 hours of admission and 17(13%)children deteriorated after 48 hours of admission. Our primary aim was to assess the correlation between the PAC score at admission(T1) and the outcome in study group i.e., children who deteriorated within 48 hours of admission.

Table 11.The characters of the deteriorated children

The cause for deterioration	**n(%)**
1. Respiratory failure requiring intubation in 48 children	48(48%)
2. Worsening respiratory distress leading to respiratory support in the form of Non-invasive ventilation or high flow oxygen therapy	23(23%)
3.Cardio-pulmonary arrest	11(11%)
4.Worsening of shock requiring > 10 mcg/kg/min Dopamine and or addition of a catecholamine / vasopressin and or increasing lactate level of more than 2 from the baseline/metabolic acidosis	17(17%)
5. . Deterioration of sensorium –i.e. drop in Glasgow Coma Scale (GCS) >/= 2 since admission to the ward	1(1%)
6.Persistent, uncontrolled seizures after two long active anticonvulsants, requiring continuous anticonvulsant infusion	1(1%)

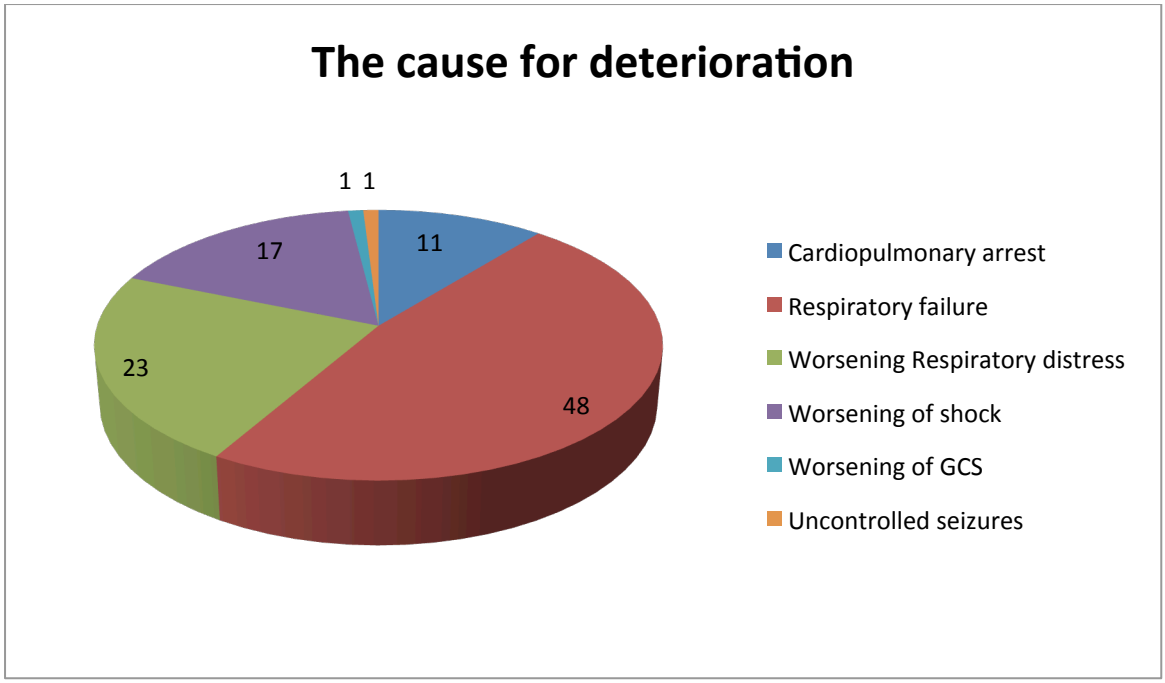
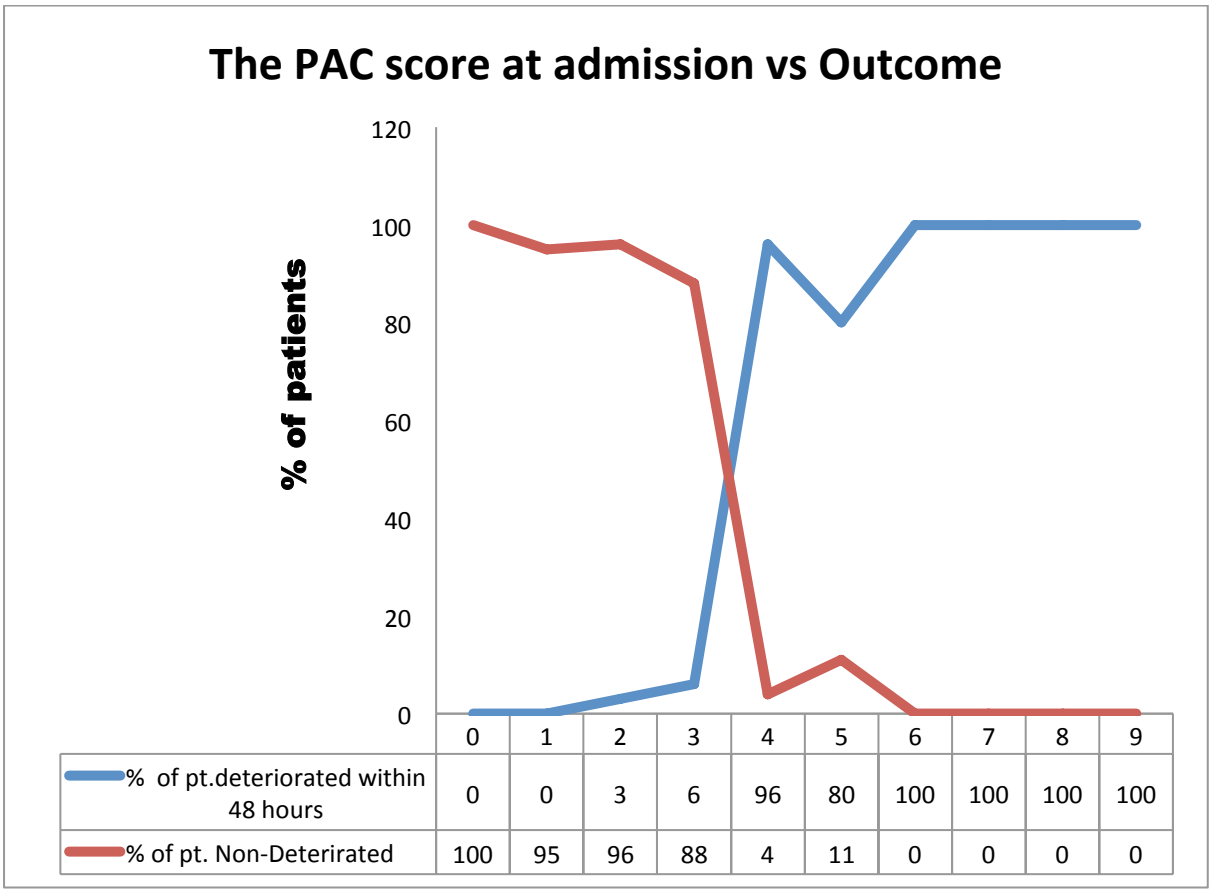


Fig-8: The cause of deterioration vs PAC score

The most common cause for the deterioration within 48 hours of admission(n=101), was respiratory failure requiring intubation, n=48(48%) followed by worsening of respiratory distress requiring Non-invasive ventilation or high flow oxygen therapy, n=23(23%). The worsening of respiratory distress in total constitute 71 %(71 out of 101 children) of the deterioration within 48 hours of admission. The other causes for deterioration are worsening of shock requiring hiking of inotropes(n=17,17%), cardiopulmonary arrest (n=11, 11%), worsening of sensorium(n=1,1%) and Persistent, uncontrolled seizures (n=1, 1%).

PAC Score Vs Outcome

The PAC- score (T1)at the time of admission and the corresponding outcome are tabulated in Table-10. Among the 560 children who required admission, 290 children had a T1 of 2 , 100 children had T1 of 1 and 39 children had T1 of ≥ 6.



	0	1	2	3	4	5	6	7	8	9
% of pt.deteriorated within 48 hours	0	0	3	6	96	80	100	100	100	100
% of pt. Non-Deterirated	100	95	96	88	4	11	0	0	0	0

Fig 9.The comparison of the PACS score and Outcome

Table 12.Sensitivity and specificity of PACS score with Likely-hood ratio

SCORE CUTOFF	SENSITIVITY	SPECIFICITY	CORRECTLY CLASSIFIED	LR+	LR-
>=0	100%	0.00%	18.57%	1.000	
>=1	100%	0.23%	18.75%	1.0023	0.0000
>=2	100%	21.67%	36.21%	1.2767	0.0000
>=3	92.08%	84.20%	85.66%	5.8273	0.0941
>=4	87.13%	99.10%	96.88%	96.4954	0.129959
>=5	59.41%	99.32%	91.91%	87.7228	0.4087
>=6	38.61%	100%	88.60%	0.6139	
>=7	20.79%	100%	85.29%	0.7921	
>=8	19.80%	100%	85.11%	0.8020	
>=9	1.98%	100%	81.80%	0.9802	
>=10	0.99%	100%	81.62%	0.9901	

Clinical Deteriorated group-There were no children with the scores of 2 and 3 who deteriorated in the first 48 hours of the admission. The high scores of 8,9,10 and above 10 were found in 1,18,1 and 1 child each.

Non-deteriorated group -There were 1 child with the score of 1,95 children with score of 2 and 277 children with score of 3. Score of 4 was found in 66 children and scores of 5 and 6 in 1 and 3 children each. There were no children with scores of 7 or above seven.

PAC score less than 4:

In our study group, 366 children had PAC score of less than 4 (1 had T1 of 0, 100 had T1 of 1, 290 had T1 of 2 and 75 had T1 of 3). Only one patient had T1 of 0 and that child recovered well. Among the 100 children who had T1 of 1, 95 (95%) recovered normally and 5 children (5%) deteriorated after 48 hours of admission. Among 290 children who had T2 of 2, 277(96%) recovered normally and 88% of children with T1 of 3 improved normally. Though the sensitivity of T1 $\geq$2 in identifying severity is 100%, but the specificity (21.6%) and the Positive likelihood ratio(1.27) is suboptimal . T1 of $\geq$ 3 has sensitivity of 92.08% with specificity of 84.2% and Positive likelihood ratio (LR+)of 5.8 in identifying the severity of illness. (Fig-6,Table:10, Table:12)

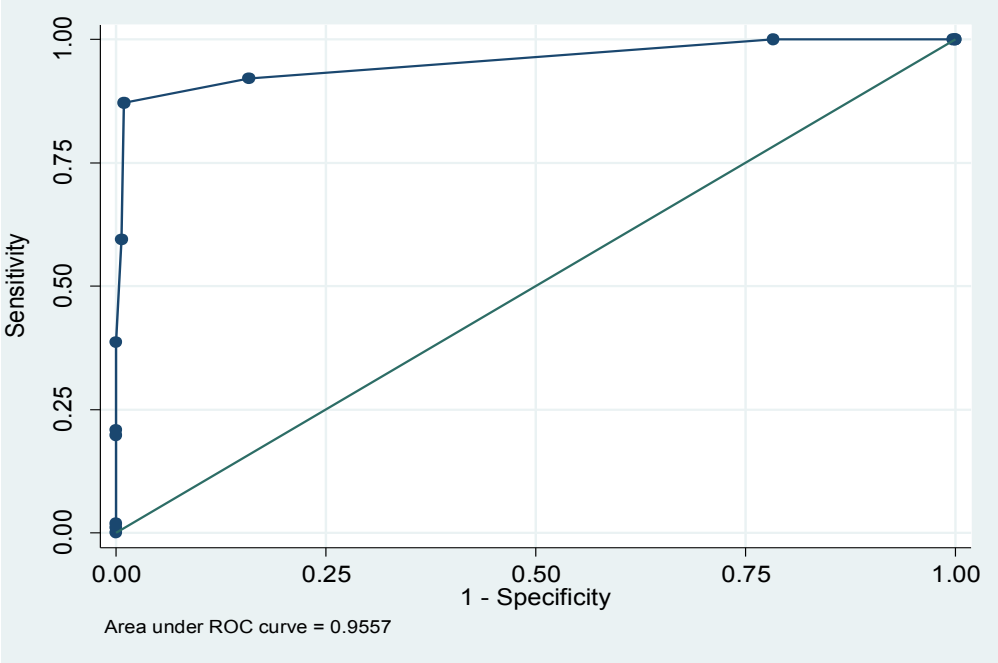
PAC score of more than 4:

Among those children who had T1 of 4, 96% (28 out of 29) deteriorated within 48 hours of admission, while 89% (21 out of 26) of children with T1 of 5 deteriorated

within 48 hours of admission. All 39 children with T1 of $\geq$ 6 deteriorated within 48 hours of admission. Though the specificity of T1 $\geq$ 6 is 100%, the sensitivity (38%) and Positive Likelihood ratio(0.61) is very low. Similarly T1 of $\geq$ 5 have specificity of 99% , but sensitivity(59.4%) and LR+ (87%). Though T1 of $\geq$ 5 or $\geq$ 6 are very specific in identifying the severity of illness, they are less reliable with respect to screening the patient.

But T1 of $\geq$ 4 has sensitivity of 87% with specificity of 99% and LR+ of 96, which means any children with PAC score of $\geq$ 4 at the time of admission have more risk of deterioration within 48 hours of admission compared to children with PAC score of <4. So PAC score of $\geq$ 4 has a fairly good chance of identifying the sick children.(Fig-9, Table-10 and table-12).

ROC Distribution (Fig.10)



Observer	ROC AREA	Std error	Asym (95%CI)	Normal
544	0.9557	0.0129	0.93050	0.98089

Table 8 ROC curve distribution and Area Under The Curve

Fig 8 shows the distribution of the scores in the receiver operator curve (ROC) with the Area under the curve(AUC) of 0.9557 with a standard error of 0.0129. The AUC which measure the test accuracy, suggest that the PAC score(AUC-0.95) is an effective scoring system and at cut-off score of $\geq$ 4 (the True positive rate was 87% and false positive rate was 1%) the chance of identifying the children who might deteriorate within 48 hours of admission is high and it is statistically significant.

Subgroup analysis of the children with co-morbidities

In our study, there were totally 27 children with co morbidities .The most common co morbidity found was children with Oncological problems (n=14),then followed by Chronic Lung disease(n=6) and then followed by Cardiomyopathy /chronic heart failure (n=4).The chronic renal failure was found in 2 children and immunodeficiency was found in one child.

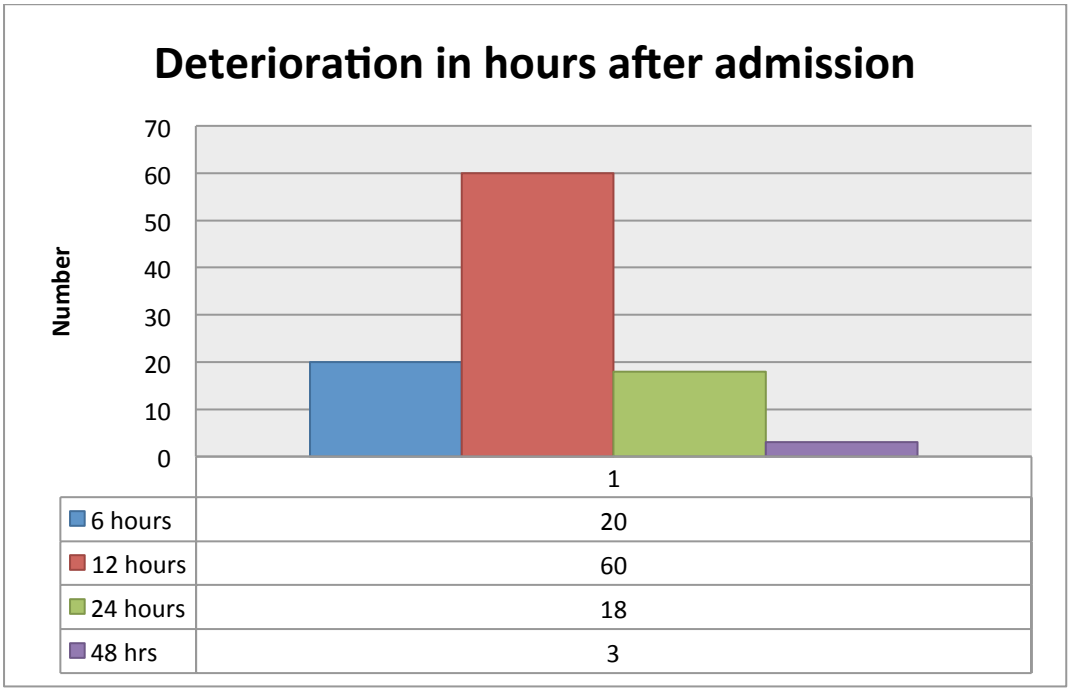
On analysis of the comorbidity scores the score had a P value of 0.42 and was found insignificant. The finding can be attributed to the low numbers of children in the study with co morbidities. It was notable that 60% (n= 16) children with co morbidities were deteriorating after 48 hours of admission. There was no difference observed in the compensated condition of the children.

Co morbidity Score	Non-Deteriorated	Deteriorated	Total
1	10	3	13
2	9	5	14
			27

Time dependant derivatives analysis

The time of admission to the casualty, time at decision for the admission of a sick child and the deterioration of the child needing sudden admission were recorded as T0,T1 and Td respectively. The score of Ti was calculated when the children were decided sick to be admitted in the ward and it was not dependant on the time of shifting to the ward which can vary according to the bed availability in such a busy hospital with limited bed strength and the logistics involved. The time variables and

the scores calculated respectively at the respective times were analysed using logistic regression and Chi square students test.



The time of deterioration was within 6 hours for 20 children, within 12 hours for 60 children ,within 24hours for 18 children and within 48 hrs for 3 children.16 Children deteriorated after 48 hours.

Table 4.Relation of the Time of admission and the time of deterioration

	Std.Err	Odds Ratio	P value	95%CI
Time	0.326364	0.9645097	0.268	0.1001015-0.0278307

On analysis, the odds ratio of the increasing score within a time period was very high -12.1 (2-3 95% CI) but the Time gap between the admission and the assessment was very insignificant with a P value of 0.2. The prediction of the deterioration on the basis of score is fully valid within the first 48 hours but not after 48 hours of admission.

DISCUSSION

DISCUSSION

The children have less potential to withhold the stress, thereby leading to rapid deterioration compared to the adults. The early identification of the severity of the illness in children can significantly decrease the mortality and morbity. In a study done by Nadkarni VM et al(1), 0.7% to 3.5% of the hospitalised children, had cardiopulmonary arrest during the course of stay, with only 15-36% of children surviving the arrest. Matthew et al,(4) showed that the patients who were transferred to the ICU after admission to the ward, had a higher mean heart rate , lower oxygen saturation than those patients who remained on the wards .Fever, hypoxia, tachycardia, mental deterioration and hypotension were significantly present before the cardiac arrests in the ward.

Hillman et al(6) and Sehein et al(7) showed that almost all critical inpatient events are preceded by warning signs like change in vital signs such as tachycardia, tachypnea, and hypotension, acute dyspnea, and change in level of consciousness.

for an average of 6–8 hours.

Several scoring systems have been developed to identify the severity of sickness in children and one among them is Pediatric Early Warning (PEWS) scoring which is

simple and objective way of assessing the severity of the illness (20). PEWS score has been modified by many authors in order to adapt to their local population( ). Though there are many scoring systems in assessing the severity of illness, there is paucity of literature in regards to Indian setting.

In our study we modified few factors in PEWS score after discussing with the expert panel (Pediatric Intensivists, Emergency Physcian, General Paediatrician, Criical Care Nurses & Critical Care Therapists) in order to adapt to our local population . Thus we formulated the Pediatric Acute Care (PAC-S) score and compared it with the outcome. The PAC score was calculated at the time of registration to PES(T0) , admission to the ward(T1) and the outcome i.e., 'Clinical Deterioration' within 48 hours of admission. The PAC-Score and the outcome were correlated and analysed . Thus, the validation of PAC-score was done in our setting.

There were total of 7,646 patients presented to the PES during our study period. Among which 660 children required admission as decided by the treating physician. We have excluded the patients who required admission after 24 hours of presentation to PES(100 children). The remaining 560 patients who have been admitted within 24

hours of presentation to PES are recruited in our study (Fig-3). The outcome was assessed for all the 560 patients.

Among the 560 patients who are admitted, 443 (80%) were discharged after complete recovery. The remaining 117(20%) children deteriorated during the course of hospital stay. Among which 101(87%) children deteriorated within 48 hours of admission and 17(13%)children deteriorated after 48 hours of admission. Our primary aim was to assess the correlation between the PAC score at admission(T1) and the outcome in study group i.e., children who deteriorated within 48 hours of admission.

Comparison of PAC- score with other scoring system:

In a large prospective multicentre study done by Vandenberg et al(23), at score of 8, the sensitivity and specificity of identifying the sick children were 82% and 93%, respectively. The score increased over 24 hours preceding urgent pediatric intensive care unit (PICU) admission ($P < 0.0001$). In 436 urgent consultations, the bedside PEWS score was higher in patients admitted to the ICU than patients who were not admitted ($P < 0.0001$). Another prospective study done at Children's Hospitals of Minnesota(24) showed that at least 87 % of the events in children could be identified by using PEWS score of more than 4(with a sensitivity of 84.2%) .

In a retrospective case control study done by Skaletzky(26), the cases transferred to the pediatric intensive care unit (PICU) based on the PEWS .The Score area under the ROC was 0.81 (95% confidence interval = 0.75-0.86). The sensitivity and specificity

for a score 2.5 were 62% and 89%, respectively. Tucker et al(27) in a prospective study described both sensitivity and specificity of PEWS for detecting clinical deterioration that results in unplanned transfer to the PICU as 93% and 84.2% respectively at a score of 4 .

Akre (30) used an outcome measure for code blue and found that the sensitivity of PEWS was 85.5%(the patient's having had a critical score within 24 hours before the event) . A total of 73.1% of patients had a critical PEWS just before the RRT or code event . The median time from a critical PEWS just before the event was 30 minutes. In another study done by Duncan(31.32) , the ability of the score to discriminate between case and control patients was assessed by logistic regression using the maximum score for the 24-hour period studied. At a threshold score of 5, the sensitivity and specificity were 78% and 95%, respectively.

In a prospective, descriptive study done by Tucker,(33) the tool was used to score 2,979 patients admitted to a pediatric hospital who required transfer to the pediatric intensive care unit and those who did not require transfer (area under the curve = 0.89, 95% CI = 0.84–0.94, $p < .001$).As the waiting time for the patients who visit the emergency department is long, Bradman et al(37) designed a study to view whether the PEWS could be useful as a triage tool and found the score above >+4 had a sensitivity of 24% and low specificity. At the same time if the score was 2 ,patient never needed admission. In a study done by Breslin (38), the association between the PEWS and the Emergency department was observed and one point increase in PEWS

increased the odds of intensive care admission by a factor of 2.09 relative to discharge and by a factor of 1.40 relative to acute care. PEWS score of 3 demonstrated 31% sensitivity and 91%specificity for admission while a score of 5 had 28%sensitivity and 96% specificity for admission.

In our study, the children that presented with a score of 2 or 3 and had 'clinical deterioration' within the first 48 hours was very negligible. Among 101 children who had T1 of 1, 95 (95%) recovered normally and 5 children (5%)deteriorated after 48 hours of admission. Among 290 children who had T1 of 2, 277(96%) recovered normally and 88% of children with T1 of 3 improved normally. Though the sensitivity of T1 $\geq$2 in identifying severity is 100%, but the specificity (21.6%) and the Positive likelihood ratio(1.27) is very suboptimal . T1 of $\geq$ 3 has sensitivity of 92.08% with specificity of 84.2% and Positive likelihood ratio (LR+)of 5.8 in identifying the severity of illness(Fig-6,Table:10, Table:12). 96% of children with T1 of 4 (28 out of 29) deteriorated within 48 hours of admission, while 89% (21 out of 26) of children with T1 of 5 deteriorated within 48 hours of admission. All 39 children with T1 of $\geq$ 6 deteriorated within 48 hours of admission. Though the specificity of T1 $\geq$ 6 is 100%, the sensitivity (38%) and Positive Likelihood ratio(0.61) is very low. Similarly T1 of $\geq$ 5 have specificity of 99% , but sensitivity(59.4%) and LR+ (87%). Though T1 of $\geq$ 5 or $\geq$ 6 are very specific in identifying the severity of illness, they are less reliable with respect to screening the patient.

But T1 of ≥ 4 has sensitivity of 87% with specificity of 99% and LR+ of 96, which means any children with PAC score of ≥ 4 at the time of admission have more risk of clinical deterioration within 48 hours of admission compared to children with PAC score of <4. So PAC score of ≥ 4 has a fairly good chance of identifying the critically ill child who has more propensity to deteriorate (Fig-6, Table-10 and table-12).

.In our data, the distribution of the scores in the receiver operator curve (ROC) with the Area under the curve(AUC) of 0.9557 with a standard error of 0.0129. The AUC which measure the test accuracy, suggest that the PAC score(AUC-0.95) is an effective scoring system and at cut-off score of ≥ 4 (the True positive rate was 87% and false positive rate was 1%) the chance of identifying the children who might deteriorate within 48 hours of admission is high and it is statistically significant.

Author	**Score**	**Cut off score**	**End point**	**ROC AUC**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Duncan	PEWS	5	Code blue	90%	78%	95%	4.2%	-
Parashuram	Bedside PEWS	8	Code blue	91%	82%	93%	9	-
Akre	Modified Brighton	4	RRT call	90%	78%	95%	4.2%	
Edwards	Melbourne criteria for activation	1	PICU admission	79%	68.3%	83.2%	3.6%	99.7%
McLellan	C-CHEWS	3	PICU admissi	92%	95.3%	76.2%	50.8	98.4%

		5	on	67.2 %	93.6%	72.9%	91.7	91
E Jacob V Pande	CMC-PACS	4	Clinical deterioration	87.1 %	99.1%	95.7%	95.7. %	97.1 %

Among the other scoring system, C-CHEWS by McLellan et al, have sensitivity of 95% but the specificity is low(76%). In contrary, the PEWS (Duncan et al), Bedside PEWS (Parashuram et al) and Modified Brighton score (Akre et al) have a specificity of 95 % but the sensitivity of 78-82%. The sensitivity and specificity of our study (PAC score) was 87% and 99%. Moreover AUC of PAC score is 0.95 which is similar to other scoring system like PEWS, Bedside PEWS , Modified Brighton etc, suggesting that the PAC score is an accurate test tool in estimating the risk of deterioration of sick children within 48 hours of admission.

SUMMARY

Summary

- This prospective observational study was done to analyze the correlation between the simple scoring system –Pediatric Acute Care (PAC-S) score developed by modifying the Pediatric Early Warning Score in children presenting to Paediatric Emergency (PES) and the risk of clinical deterioration requiring high dependency or intensive care within 48 hours of admission to the pediatric wards.
- The study was conducted at the Paediatric Emergency Service (PES)and the pediatric wards of CMC, Vellore
- The primary outcome was defined as 1. Cardio-pulmonary arrest ,2. Respiratory failure requiring intubation,3. Worsening respiratory distress leading to respiratory support in the form of Non-invasive ventilation or high flow oxygen therapy ,4. Worsening of shock requiring > 10 mcgm/kg/min Dopamine and or addition of a catecholamine / vasopressin and or increasing lactate level of more than 2 from the baseline/metabolic acidosis,5. Deterioration of sensorium –i.e. drop in Glasgow Coma Scale (GCS) >/= 2 since admission to the ward and 6. Persistent, uncontrolled seizures after two

long active anticonvulsants, requiring continuous anticonvulsant infusion.. The admitted children were followed up to 48 hours for the clinical deterioration.

- **Results** : Among the 560 patients who are admitted to the wards, 443 (80%) were discharged after complete recovery. The remaining 117(20%) children deteriorated during the course of hospital stay. Among which 101(87%) children deteriorated within 48 hours of admission and 16(13%)children deteriorated after 48 hours of admission
- The most common cause for the deterioration within 48 hours of admission(n=101), was respiratory failure requiring intubation, n=48(48%) followed by worsening of respiratory distress requiring Non-invasive ventilation or high flow oxygen therapy, n=23(23%)
- At a score of $\geq$ 4 The score has sensitivity of 87% with specificity of 99% and LR+ of 96 and AUC of 0.95.Hence children with PAC score of $\geq$ 4 at the time of admission have more risk of deterioration within 48 hours of admission.

CONCLUSION

CONCLUSION

- The Paediatric Acute Care Score (PACS) was developed based on the standard validated Paediatric Early Warning Score which includes parameters of acute clinical examination – Behaviour, Cardiovascular and Respiratory parameters. We also included the risk factors like immunodeficiency, neutropenia, heart and renal disorders

- PAC-S is an accurate scoring system (AUC-0.95) in identifying the risk of clinical deterioration in acutely ill children within 48 hours of admission

- The children with PAC- Score of $\geq$ 4 have more chance of deterioration within 48 hours of admission compared to those with PAC score of <4.(Sensitivity-87% and Specificity-99%)

Limitations of the study

- During the study period, there were no epidemics of Dengue or Bronchiolitis which are very frequent locally. These epidemics delay the care of the children with prolonged waiting time which could not be captured in this study

- There were very less children with co-morbidities to be included in the score validated.

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ANNEXURES

CONSENT FORM

PEADIATRIC ACUTE CARE SCORE STUDY

CHRISTIAN MEDICAL COLLEGE, VELLORE.

Information Sheet

Dear parent, we are conducting a study to develop a prediction scale (score), to identify the sick children and their risk of deterioration within 48 hours of admission to the paediatric ward. You are requested to participate in this study .

Why children are at increased risk of deterioration and ICU admission?

The sick children are very fragile and their condition can worsen more rapidly as compared to the adults. Their potential to withstand the stress during an illness is very low compared to adults, which may lead to rapid deterioration and ICU admission. So timely intervention is necessary to prevent untoward events.

Why are we doing this study?

When children present to the paediatric casualty, they are prioritized based on the severity of their illness and treatment will be initiated as per the standard protocol. In spite of the standard treatment protocol, some children worsen very rapidly requiring ICU care within 48 hours of admission. The best way to treat such patient is to recognize the sick child at the first contact with medical care professional. We are developing a score depending on studies done in western countries to assess the

condition of the child early so that the appropriate treatment can be started on time. We will only assess your child's condition(blood pressure, temperature pulse , and sensorium) at presentation and at admission. He/she will be followed up for 48 hours after admission to assess for any deterioration in his condition. There will be no extra investigations done for your child in this study and moreover there is no deviation from the current standard treatment protocol . Your child will receive the treatment as per the standard protocol, irrespective of his participation in this study.

How can I be part of the study?

After reading this information sheet and clarifying your doubts, you are welcome to participate in this study by giving your written informed consent.

Can I opt out of the study?

Yes. You are allowed to withdraw from study at any point of time. Your participation and or your withdrawal from the study is entirely voluntary . Your child will receive treatment as per the current standard treatment protocol irrespective of your participation/withdrawal from the study.

How will the scoring of my child help?

Your child will not be directly benefitted from this study, but this study will help to formulate a prediction score to indentify the sick children as early as possible and to intervene at the right time.

Is there any side-effects in this study?

No. The parameters which we assess are part of routine clinical examination and there is no deviation from the standard treatment protocol. Your child will receive same treatment irrespective of his/her participation in this study. By participating in this study, your child will not develop any side-effects.

Will my personal details be kept confidential?

Yes. Your child's details are kept confidential. The results of the study will be published in a medical journal but your child's identity will not be revealed anywhere. However, your child's medical notes can be reviewed by people associated with this study without your additional permission.

PEADIATRIC ACUTE CARE SCORE STUDY

CHRISTIAN MEDICAL COLLEGE, VELLORE.

Informed Consent

Study Title: PACS STUDY

Study Number: _____

Subject's Initials: _____

Subject's Name: _____

Date of Birth / Age: _____

(i) I confirm that I have read and understood the information sheet dated _____ for the above study and have had the opportunity to ask questions. [ ]

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. [ ]

(iii) I understand that the Sponsor of the study, others working on the Sponsor's behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published. [ ]

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). [ ]

(v) I agree to take part in the above study. [ ]

Signature (or Thumb impression) of the parent/guardian

Date: _____/_____/_____

Signature of Investigator: _____
Date: _____/_____/_____

PROFORMA FOR DATA COLLECTION

PEDIATRIC ACUTE CARE SCORE (PACS) STUDY

DEPARTMENT OF PEDIATRICS, CHRISTIAN MEDICAL COLLEGE, VELLORE

1.Name: **2.Age:**
3.Gender:Male/female

4.Hospital number: **5.Unit:** **6.Date:**

7.Priority as per TRIAGE : I / II / III

8.Primary diagnosis:……

9.Time at presentation (T0): ……..A.M/P.M

10.PACS assessment at T0:

	A	B	C	D
Behaviour	Lethargic or confused or reduced pain response	Irritable and unconsoble or Parents concerned	Sleeping or irritable and consolable	Playing or appropriate
Cardiovascular	Grey or cyanotic & mottled or CRT > 5 Secs or Tachycardia 30 above or bradycardia for age	Grey or Cyanotic or CRT >4 secs OR Tachycardia 20 above normal parameters	Pale or dusky or CRT 3 sec	Pink or CRT 1-2 sec
Respiratory	> 30 above or > 5 below normal with retractions or tracheal tug or grunting or >50 %Fio2 or 8 liters/min O2	>20 above normal or using accessory muscles or 40-49% %Fio2 or >6 lit/min O2	>10above normal parameters Or Using accessory muscles or 30 -39%% Fio2 or >3 lit/min O2	Within normal parameters for age , No recessons

11.Time at which admission was decided (T1):……A.M/P.M

12.PACS assessment at T1:

	A	B	C	D
Behaviour	Lethargic or confused or reduced pain response	Irritable and unconsoble or Parents concerned	Sleeping or irritable and consolable	Playing or appropriate
Cardiovascular	Grey or cyanotic & mottled or CRT > 5 Secs or Tachycardia 30 above or bradycardia for age	Grey or Cyanotic or CRT >4 secs OR Tachycardia 20 above normal parameters	Pale or dusky or CRT 3 sec	Pink or CRT 1-2 sec
Respiratory	> 30 above or > 5 below normal with retractions or tracheal tug or grunting or >50 %Fio2 or 8 liters/min O2	>20 above normal or using accessory muscles or 40-49% %Fio2 or >6 lit/min O2	>10above normal parameters Or Using accessory muscles or 30 -39%% Fio2 or >3 lit/min O2	Within normal parameters for age , No recessons

***reference standard for heart rate and respiratory rate in children:**

Age	Heart rate(per min)	Respiratory rate(per min)
1-12months	**100-180**	**35-40**
13 months – 3years	**70-110**	**25-30**
4-6 years	**70-110**	**21-23**
7-12 years	**70-110**	**19-21**
13-19 years	**55-90**	**16-18**

13. Co-Morbid factors:

Pathology	A	B
Oncology	**Neutropenic**	**Non-neutropenic**
Chronic pulmonary pathology	**present**	**Absent**
Chronic Cardiac pathology: CHD/Cardiomyopthy	**compensated**	**De-compensated**
Chronic renal pathology	**present**	**absent**
Immunodeficiency state	**present**	**absent**

Others;……..

14. PACS assessment: TO-

T1-

15. Outcome: A. No clinical deterioration

B. Clinical deterioration within 48 hours of admission to the pediatric ward.

1. Cardio-pulmonary arrest
2. Respiratory failure requiring intubation
3. Worsening respiratory distress leading to respiratory support in the form of Non-invasive ventilation or high flow oxygen therapy
4. Worsening of shock requiring > 10 mcgm/kg/min Dopamine and or addition of a catecholamine / vasopressin and or increasing lactate >2 from baseline value /metabolic acidosis.
5. Deterioration of sensorium –i.e drop in Glasgow Coma Scale (GCS) >/= 2 since admission to the ward
6. Persistent, uncontrolled seizures after two long active anticonvulsants are added requiring anticonvulsant continuous infusion